

**INNOVATION AND INFORMATION TECHNOLOGY:  
THE GOVERNMENT, UNIVERSITY, AND INDUSTRY  
ROLES IN INFORMATION TECHNOLOGY RESEARCH  
AND COMMERCIALIZATION**

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**FIELD BRIEFING**  
BEFORE THE  
**COMMITTEE ON SCIENCE**  
**HOUSE OF REPRESENTATIVES**  
ONE HUNDRED NINTH CONGRESS

SECOND SESSION

MAY 5, 2006

**Serial No. 109-48**

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# CONTENTS

May 5, 2006

Witness List .....	Page 2
Briefing Charter .....	3

## Opening Statements

Statement by Representative Lamar S. Smith, Presiding Chairman, Committee on Science, U.S. House of Representatives .....	9
Written Statement .....	10
Statement by Representative Michael T. McCaul, Member, Committee on Science, U.S. House of Representatives .....	11
Written Statement .....	13

## Witnesses:

Dr. Peter A. Freeman, Assistant Director for Computer and Information Science and Engineering Directorate (CISE), National Science Foundation	
Oral Statement .....	15
Written Statement .....	19
Biography .....	21
Mr. Pike Powers, Partner at Fulbright & Jaworski L.L.P.; Chairman of the Texas Technology Initiative	
Oral Statement .....	22
Written Statement .....	27
Biography .....	31
Financial Disclosure .....	33
Dr. Juan M. Sanchez, Vice President for Research; Temple Foundation Endowed Professor in Mechanical Engineering, University of Texas at Austin	
Oral Statement .....	34
Written Statement .....	35
Biography .....	37
Financial Disclosure .....	39
Dr. Randal K. Goodall, Director of External Programs, SEMATECH	
Oral Statement .....	39
Written Statement .....	43
Biography .....	47
Financial Disclosure .....	48
Dr. Neil Iscoe, Director, Office of Technology Commercialization, University of Texas at Austin	
Oral Statement .....	49
Written Statement .....	51
Biography .....	52
Financial Disclosure .....	54
Discussion .....	55



**INNOVATION AND INFORMATION TECHNOLOGY: THE GOVERNMENT, UNIVERSITY, AND INDUSTRY ROLES IN INFORMATION TECHNOLOGY RESEARCH AND COMMERCIALIZATION**

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**FRIDAY, MAY 5, 2006**

HOUSE OF REPRESENTATIVES,  
COMMITTEE ON SCIENCE,  
*Austin, TX.*

The Committee met, pursuant to call, at 2:00 p.m., in Salon B, 4th Level, of the Hilton Hotel at 500 East 4th Street in Austin, Texas, Hon. Lamar Smith [Chairman of the Briefing] presiding.

**COMMITTEE ON SCIENCE  
U.S. HOUSE OF REPRESENTATIVES**

**“Innovation and Information Technology: The Government,  
University, and Industry Roles in Information Technology  
Research and Commercialization”**

Friday May 5, 2006

2:00 PM – 4:00 PM  
Hilton Hotel  
Salon B, 4<sup>th</sup> Level  
500 East 4th Street  
Austin, Texas

**Witness List**

**Dr. Peter Freeman**

Assistant Director for Computer and Information Science and Engineering, National Science  
Foundation

**Mr. Pike Powers**

Partner, Fulbright & Jaworski L.L.P.

**Dr. Juan Sanchez**

Vice President for Research, The University of Texas at Austin

**Dr. Randal Goodall**

Director, External Programs, SEMATECH

**Dr. Neil Iscoe**

Director, Office of Technology Commercialization, The University of Texas at Austin

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FIELD BRIEFING CHARTER

**COMMITTEE ON SCIENCE  
U.S. HOUSE OF REPRESENTATIVES****Innovation and Information Technology:  
The Government, University, and Industry  
Roles in Information Technology Research  
and Commercialization**FRIDAY, MAY 5, 2006  
2:00 P.M.–4:00 P.M. (CDT)  
SALON B, HILTON HOTEL  
500 EAST 4TH STREET  
AUSTIN, TEXAS**1. Purpose**

On Friday, May 5, 2006, the House Science Committee will hold a field briefing to examine how information technology research and development (R&D) sponsored or performed by government, industry, and universities contributes to U.S. competitiveness in the global information technology market.

**2. Witnesses**

**Dr. Peter Freeman** is the Assistant Director for Computer and Information Science and Engineering at the National Science Foundation.

**Dr. Randal Goodall** is the Director of External Programs at SEMATECH, an association of companies supporting pre-competitive semiconductor technology development.

**Dr. Neil Iscoe** is the Director of the Office of Technology Commercialization at The University of Texas at Austin.

**Mr. Pike Powers** is a Partner at Fulbright & Jaworski L.L.P., and chairman of the Texas Technology Initiative, which aims to retain and attract advanced technology industries, coordinate advanced technology activities, and accelerate commercialization from R&D to the marketplace.

**Dr. Juan Sanchez** is the Vice President for Research at The University of Texas at Austin.

**3. Brief Overview**

- Federal support for information technology R&D has been a key to the development of the information technology industry. The 2003 National Academy of Sciences report *Innovation in Information Technology* lists 19 areas in which federally-sponsored fundamental research underpinned the innovations that eventually became multi-billion dollar information technology industries. Examples include the Internet and the World Wide Web, parallel and relational databases, data mining, and speech recognition.
- Academic computer science research has direct relevance to the information technology industry. University research in computer science is funded by a several federal agencies, but the largest contributor is the National Science Foundation (NSF), which accounted for about 65 percent of the roughly \$1.1 billion of federal funding for research performed at universities and colleges in mathematics and computer sciences in fiscal year 2004 (FY04).
- Private companies also conduct information technology R&D. While the majority of corporate R&D is focused on product and process development, companies also conduct fundamental research in their own labs and provide fiscal and in-kind support for university research and education in information technology.
- The success of the information technology R&D enterprise depends on effective partnership among government, industry, and universities. The briefing

will focus on highlighting the contributions of each group, especially how all players interact in the support and utilization of university research.

#### 4. Overarching Questions

The briefing will address the following overarching questions:

- How does the federal investment in information technology R&D promote innovation in information technology and foster the development and commercialization of new applications?
- What role does university research play in innovation in information technology? How do universities balance federal and industry support for research projects? How do companies balance support for research conducted within the company and research performed at universities? What are the barriers to use of university results in commercialization of new information technology products?
- What areas of information technology research and what type of programs should the Federal Government emphasize to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?

#### 5. Background

Many of the technologies that enabled electronic commerce to take off in the 1990s are based on research initially conducted at universities and funded by federal agencies, such as NSF and the Defense Advanced Research Projects Agency (DARPA). The 2003 National Academy of Sciences report *Innovation in Information Technology*<sup>1</sup> lists 19 areas in which federally sponsored fundamental research underpinned the innovations that eventually became multi-billion dollar information technology industries. Examples relating to e-commerce include web browsers, search engines, cryptography methods that allow secure credit card transactions, databases to manage information and transactions, and the protocols and hardware underlying the Internet itself. Often, the unanticipated results of such research are as important as the anticipated results. For example, the early research that led to e-mail and instant messaging technologies was originally done in the 1960s as part of a project examining how to share expensive computing resources among multiple simultaneous and interacting users.

These innovations have helped create an information technology sector that is credited for nearly 30 percent of real growth in the U.S. gross domestic product from 1994 to 2000 and that accounted for 29 percent of all U.S. exports in 2005.<sup>2</sup> In 2005, Texas companies exported \$31 billion in computers and electronic products; this industry has been Texas's largest source of exports since at least 1997.<sup>3</sup> The military also depends heavily on the information technology sector's products to meet its critical information technology needs.

Since the pace of change in information technology products is so rapid, companies' main competitive advantage often comes from being first to market with a particular product or feature. If the U.S. research community isn't producing the ideas, or if the ideas are classified, it is less likely that U.S. companies will be the first to benefit from the research results.

Academic research also contributes to the training of the information technology workforce. Research grants support graduate students, and undergraduate and graduate computer science and engineering programs at universities produce the software developers and testers, hardware designers, and other personnel that power the computing and communications industries and the industries that depend on information technologies. (For example, automotive and manufacturing companies rely on modeling and simulation for product development and production management, and the financial services sectors utilize information technology for modeling markets and securing financial transactions.)

##### *Federal Agencies That Support Academic Information Technology Research*

University research in computer science is funded by several federal agencies, including the Department of Defense, the National Institutes of Health, the National Aeronautics and Space Administration, and the Department of Energy, but the largest contributor is NSF, which accounted for about 65 percent of the roughly \$1.1

<sup>1</sup> Computer Science and Telecommunications Board, National Academies, *Innovation in Information Technology*, National Academy Press (2003), pages 6–7.

<sup>2</sup> Data from the Information Technology Industry Council.

<sup>3</sup> From the Business and Industry Data Center, Texas Department of Economic Development. Available on line at <http://www.bidc.state.tx.us/overview/2-2te.htm>.

billion of federal funding for research performed at universities and colleges in mathematics and computer sciences in FY04.<sup>4</sup>

Coordination among the agencies primarily occurs through working groups organized under the multi-agency Networking and Information Technology Research and Development (NITRD) Program, which operates under the auspices of the White House Office of Science and Technology Policy. The total estimated federal spending on networking and information technology R&D in FY06 is \$2.9 billion; this includes funding for government laboratories and industry, as well as university research. The breakdown by agency and proposed FY07 spending is outlined in Table 1.

Table 1. Estimated Federal Spending on Networking and Information Technology R&D (dollars in millions)

Agency	FY06 (Estimated)	FY07 (Requested)
Department of Defense	1053	1081
NSF	810	904
Department of Health and Human Services	562	548
Department of Energy	291	387
National Institute of Standards and Technology	39	43
National Oceanic and Atmospheric Administration	16	23
National Aeronautics and Space Administration	78	82
Environmental Protection Agency	6	6
<b>Total</b>	<b>2855</b>	<b>3074</b>

Areas of research supported by these agencies include supercomputing, cyber security, networking, software design and productivity, human-computer interaction, and workforce development issues. In general, each agency focuses on information technology research in areas relevant to its mission; for example, the Department of Health and Human Services and the National Institute of Standards and Technology are working on technologies and standards for information technology applications in health care, while the National Oceanic and Atmospheric Administration develops and implements improved weather modeling techniques.

#### *National Science Foundation*

At NSF, projects are selected for funding through a competitive, peer review process, in which NSF brings together panels of experts in a given field to review proposals anonymously. Researchers can send project proposals to NSF either in response to agency-issued requests for proposals in specific areas or as unsolicited proposals.

Computer science research at NSF is conducted almost entirely in the Computer and Information Sciences and Engineering Directorate (CISE). Relevant CISE activities include support for investigator-initiated research in all areas of computer and information science and engineering and support for the education and training of the next generation of computer scientists and engineers.

Research supported by CISE is designed to promote advances in new software, hardware, systems, and algorithms. Specific areas of research include work relevant to homeland security, such as cyber security, machine translation, artificial intelligence, computer vision, robotics, and techniques for information retrieval, analysis and display (“connecting the dots”); research on new supercomputing hardware and software architectures; projects to support the systematic re-design of current network systems, such as the Internet, to make them more secure and stable and able to handle more traffic; and explorations of totally new approaches to computing, such as quantum and bio-computing.

At the University of Texas at Austin, NSF funds projects in a wide variety of areas, including research on improving security and robustness by building distributed services that tolerate buggy, selfish, or malicious elements on the network; modeling of wireless networks to allow the design, development, and testing of the next generation of wireless network protocols; and new techniques for mining large data sets and delivering results in a timely manner. NSF also helps support the

<sup>4</sup>Data on support for university research is from *Academic Research and Development Expenditures: Fiscal Year 2003* (NSF 05-320), National Science Foundation, Division of Science Resources Statistics, (2005). Available on line at <http://www.nsf.gov/statistics/nsf05320/>.

Texas Advanced Computing Facility, a computing facility that provides information technology resources to researchers and students, including supercomputing systems, advanced scientific visualization, and massive data storage/archival systems.

Another NSF-supported program provides research experiences for undergraduates, including a program in which students from all over Texas come to the University of Texas at Austin for 10 weeks in the summer to perform research in communications applications, including networking, wireless, security, and signal processing. Particular effort is made to ensure participation by minorities and students from disadvantaged communities.

At the University of North Texas, researchers are developing a geographically distributed, secure test bed to analyze vulnerabilities in Voice over Internet Protocol (VoIP)—an increasingly popular technology that turns audio signals into digital data that can be transmitted over the Internet. The project will investigate voice spam prevention (VoIP phone systems can be spammed like e-mail), attacks on networks and Internet resources that render them unavailable (denial of service), quality of service, and 911 service dependability.

#### *Non-Federal Support for University Research and Development in Information Technology*

The Federal Government is the largest source of funds for university information technology R&D. In FY03 in all fields, universities spent \$40 billion on research and development, and \$25 billion of that was provided by the Federal Government. The remainder came from institutional funds (\$8 billion), State and local government (\$3 billion), industry (\$2 billion), and a variety of other sources (\$2 billion). In FY03 in computer sciences, the overall non-federal support was \$279 million, more than double the FY96 level.

Non-federal support for university programs often supports programs that supplement or expand the goals of federally funded research. An example in research is the Microelectronics Research Center at the University of Texas at Austin, which contains a mix of complementary programs, including a nanotechnology facility funded by NSF and an Advanced Materials Research Center supported by SEMATECH and the Texas Enterprise Fund (State funds). An example in education is the recently announced partnership between SEMATECH and several Texas institutions of higher education, including Austin Community College and the University of Texas at Austin. This workforce program will include development of new nanoelectronics curriculum materials and internship experiences for 160 community college, undergraduate, and graduate students.

#### *Technology Transfer and Information Technology*

The results of information technology research conducted at universities find their way into commercial products via a variety of paths. Most formally, universities can transfer technology by protecting (via patents and copyrights) specific results of research conducted on their campuses and then licensing the new inventions to industry for commercial development. Universities also seed innovation in the information technology industry by attracting and cultivating entrepreneurial faculty, who form or support the formation of spin-off companies. In both of these mechanisms, the efficiency and ultimate success of technology transfer from the university depends not only on the federal support for research on campus, but also on federal intellectual property laws and policies and on the willingness of the venture capital community to fund technology commercialization.

Finally, a very significant, although difficult to measure, impact of university research on commercialization comes from the education mission of academic institutions. Given the rapidly changing nature of information technology, the most efficient method of technology transfer may simply be industry's hiring of students who have worked on research projects at universities; the skills of the next generation workforce informs and enables the development of the next generation technology.

#### *Industry Research and Development in Information Technology*

In 2001 in the U.S., \$60 billion was spent on industrial research and development for computer and electronic products and software by companies, the Federal Government and others.<sup>5</sup> \$4.5 billion of that sum was spent in Texas. While the majority of corporate R&D is focused on product and process development, companies also support some longer-term fundamental research (of the \$60 billion, \$1 billion was for basic research).

<sup>5</sup>Data in this paragraph is from *Research and Development in Industry: 2001* (NSF 05-305), National Science Foundation, Division of Science Resources Statistics (2005). Available on line at <http://www.nsf.gov/statistics/nsf05305/>.

The fundamental, widely-disseminated research conducted at universities and often supported by the Federal Government complements the focused development projects undertaken in industry. However, the relationship between these two types of activities is often not linear. In the National Academy of Sciences report,<sup>6</sup> the R&D for the 19 areas in which federally-sponsored fundamental research underpinned the innovations that eventually became multi-billion dollar information technology industries usually involved a complex history of interwoven university and industry efforts. In some cases, the original idea came from industry, but was not commercialized until federally-supported research at universities advanced the technology. In other cases, start-up companies spun off from universities were critical players, by providing that new technologies could be introduced into established markets or by being acquired by larger companies. As the National Academy of Sciences report notes, “strong research institutions are recognized as being among the most critical success factors in high-tech economic development,” and it cites seven examples where the positive impact of thriving research universities can be seen, including Boston, Seattle, and Austin.<sup>7</sup>

*World Congress on Information Technology*

This briefing is being held concurrently with the 15th World Congress on Information Technology (WCIT) in Austin, Texas. WCIT is a biennial summit hosted by the World Information Technology and Services Alliance in which senior executives, government officials, and futurists from over 80 countries meet to discuss the future of information technology. This year’s WCIT includes a Global Impact Program, focused on privacy and security, digital access, and health care; an Innovation Exchange Program, focused on technology, trade, and investment; and an Innovation Exchange Exhibition.

**6. Witness Questions**

The witnesses were asked to address the following questions in their testimony:

*Dr. Peter Freeman:*

- How does the National Science Foundation (NSF) investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?
- How does NSF work with industry to support information technology research? How does NSF facilitate the use of the research it supports in commercialization of new information technology products?
- How do the topics and types of NSF programs in information technology research complement other agencies’ programs in this area? How do they complement the focus and investments of industry research programs?

*Dr. Randal Goodall:*

- How does the federal investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?
- What role does university research play in innovation in information technology? How do companies balance support for research conducted within the company and research performed at universities? What are the barriers to use of university results in commercialization of new information technology products?
- What areas of information technology research and what type of programs should the Federal Government support to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?

*Dr. Neil Iscoe:*

- How does the federal investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?

<sup>6</sup>Computer Science and Telecommunications Board, National Academies, *Innovation in Information Technology*, National Academy Press (2003), pages 11–12.

<sup>7</sup>Computer Science and Telecommunications Board, National Academies, *Innovation in Information Technology*, National Academy Press (2003), page 20.

- What role does university research play in innovation in information technology? What are the barriers to use of university results in commercialization of new information technology products?
- What areas of information technology research and what type of programs should the Federal Government support to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?

*Mr. Pike Powers:*

- How does government investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?
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*Dr. Juan Sanchez:*

- How does the federal investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?
- What role does university research play in innovation in information technology? How do universities balance federal and industry support for research projects? What are the barriers to use of university results in commercialization of new information technology products?
- What areas of information technology research and what type of programs should the Federal Government support to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?

Chairman SMITH. This briefing of the Committee on Science will come to order. I don't think I necessarily need a gavel. This doesn't look like too raucous of a crowd. I am delighted to be here with my colleague, Mike McCaul. He and I share an interest in the subject at hand. It was Mike McCaul who approached me with the idea of our briefing today. It was a good idea and it is coming to fruition right now.

I want to thank everyone that is in the audience who has interest in this particular subject. You are going to be hearing from witnesses today who are experts in their field and who have a unique view of the subject and who have good recommendations for us to heed as well.

The procedure today is I am going to recognize myself for an opening statement and then Congressman McCaul for his opening statement and introduce the witnesses and then we will get to their testimony immediately. We are probably not going to be as strict as we usually are in Washington, D.C. as far as enforcing the five-minute rule on testimony. We hope that you won't go too far over the five minutes. Nor are we going to enforce the five-minute rule on ourselves as far as questions go. There will be ample time for both testimony and the questions as well.

Also I would like to introduce to my right Elizabeth Grossman. Elizabeth came down from Washington for today's briefing and has been instrumental in putting it together. She is Staff Director of the Subcommittee on the Science Committee and has just done excellent work with us here today. Both Congressman McCaul and I are Members of the Science Committee and we also share another committee together, Homeland Security, which is at least indirectly related to the subject at hand as well.

Let me recognize myself for an opening statement. First of all, it is nice to be back home in Texas. We meet as the successful World Congress on Information Technology comes to a close next door at the Convention Center. Our topic today is "Innovation and Information Technology: The Government, University, and Industry Roles in Information Technology Research and Commercialization."

What better place to hold such a hearing as this than Austin, Texas, one of the most energetic high technology centers in our nation.

As is evident from the distinguished panel of witnesses assembled here today, the government at all levels, the internationally recognized University of Texas, and a diverse and dedicated private sector work together to bring innovations to consumers the world over.

Not only do those innovations better our lives, they are also vital to our future economic prosperity. Intellectual property industries account for half of our exports and 40 percent of our increase in productivity in America. If we are to maintain a competitive advantage over China, India, and many other emerging countries, we must protect intellectual property rights and enhance our ability to innovate.

To do that, we must leverage the unique strengths of each of the three sides of this triangle: government, universities, and industry. Unconstrained by the need to turn a profit, government can take

research risks that private sectors cannot. For example, no private industry could have ever put a man on the moon, but the government did.

Among many other things, the space program led to wonders like satellite television, satellite radio, and the global positioning system that now seem commonplace. Somewhere between government and private industry, a university can concentrate resources and intellectual power more quickly than can government, but without the need to make a profit.

Finally, industry takes these innovations and turns them into products that make our lives better. Without that final step, the research process can lack meaning for the typical person. While few of us really understand how iPods and Blackberries work, many of us enjoy their benefits. In fact, Congressman McCaul has a Blackberry in his pocket right now.

When we do, we grasp what all this research does for us. These kinds of innovations improve our lives and that is the point of the industry contribution to the research process.

Let me digress for a moment and just touch on another subject that is important to the picture, education. If we are to continue to lead the world in innovation, we must strengthen our math and science education. Just a couple of months ago I stood with other members of the Speaker's High Tech Working Group to unveil competitiveness legislation.

This legislation provided for loan forgiveness for math and science teachers as well as funding for new science Master's Degree programs to enhance America's talent pool. I am hopeful that this legislation can be enacted soon. I also want to commend the University of Texas for the work that it is doing in this area at the Dana Center and with the Texas Essential Knowledge and Skills programs.

Now, turning back to the topic at hand, all three sides of the triangle, government, university, and industry are critical. Austin is a national model for the vibrant creative process that the close collaboration among them generates. I am privileged to represent a community that contributes so much to high technology research and innovation. And, of course, I look forward to the witnesses' testimony today.

Let me acknowledge at the outset those who have come today to provide testimony. They have all put an incredible amount of time and effort into their testimony. We do appreciate the court reporter to my right who will be taking careful note of everything that you say. Congressman McCaul and I will be putting this in the record and passing it on not only to the Science Committee but to other committees as well when we get back to Washington. This information that we hear today and suggestions that you all have will be transferred into policy and/or legislation.

Thank you all for being here. It is a happy pleasure to be here. I now recognize my colleague Congressman McCaul.

[The prepared statement of Chairman Smith follows:]

PREPARED STATEMENT OF REPRESENTATIVE LAMAR S. SMITH

It is nice to be back home in the 21st District of Texas to have this briefing of the Committee on Science.

We meet as the successful World Congress on Information Technology comes to a close next door at the Convention Center.

Our topic today is “Innovation and Information Technology: The Government, University, and Industry Roles in Information Technology Research and Commercialization.”

What better place could there be to hold such a briefing than Austin, Texas—one of the most energetic high technology centers in our nation?

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Not only do those innovations better our lives, they are also vital to our future economic prosperity.

Intellectual property industries account for half of our exports and 40 percent of our economic growth.

If we are to maintain a competitive advantage over China, India and the many other emerging countries, we must protect intellectual property rights and enhance our ability to innovate.

To do that, we must leverage the unique strengths of each of the three sides of this triangle: government, universities, and industry.

Unconstrained by the need to turn a profit, government can take research risks that private industry never could.

For example, no private industry could have ever put a man on the Moon, but the government did.

Among many other things, the space program led to wonders like satellite television, satellite radio, and the global positioning system that now seem commonplace.

Somewhere between government and private industry, a university can concentrate resources and intellectual power more quickly than can government, but without the need to make a profit.

For example, one project that I have secured federal funding for is the remarkable Petawatt Laser Project at the University of Texas.

When it is completed, it will be one of the strongest lasers ever constructed, and it will have numerous applications.

Finally, industry takes these innovations and turns them into products that make our lives better.

Without that final step, the research process can lack meaning for the typical person.

While few of us really understand how iPods and Blackberries work, many of us enjoy their benefits.

When we do, we grasp what all this research does for us.

These kinds of innovations improve our lives and that is the point of the industry contribution to the research process.

Let me digress for a moment and just touch on one other important aspect of this picture: education.

If we are to continue to lead the world in innovation, we must strengthen our math and science education.

Just a couple of months ago, I stood with other members of the Speaker’s High Tech Working Group to unveil competitiveness legislation.

This legislation provided for loan forgiveness for math and science teachers as well as funding for new science Master’s degree programs to enhance America’s talent pool.

I am hopeful that this legislation can be enacted soon.

I also want to commend the University of Texas for the work that it is doing in this area at the Dana Center and with the Texas Essential Knowledge and Skills program.

Now, turning back to the topic at hand, all three sides of the triangle, government, university, and industry are important.

Austin is a national model for the vibrant creative process that the close collaboration among them produces.

I am privileged to represent a community that contributes so much to high technology research and innovation.

And I look forward to hearing the testimony of our outstanding witnesses.

Mr. McCAUL. Thank you, Mr. Chairman. First I want to thank you for agreeing to do this. I think it adds a new dimension to the IT world of Congress. Also I want to thank you for your leadership

on this issue. You have been an important part of this committee, particularly the intellectual property issues as it impacts the IT community. I look forward to working with you to enhance what we already have. Again, thank you for your leadership.

I want to thank all the witnesses for being here. There are a lot of familiar faces. A lot of times the hearings are very formal. This one may be a little more entertaining and perhaps fun. We are here to also listen and learn from the experts and you are, indeed, the experts. I want to thank Elizabeth for coming down and spending time with us in Austin. I hope you enjoy your stay in Austin.

I can't tell you how proud I am of Austin this week as the world turns its eyes to my hometown. I know that Austin is proud to call itself the technology capital of the World, and the home of the University of Texas, which does so much great work in research and development. Therefore, it is fitting in my view that the IT World Congress showcase what we have here.

The companies and leaders of innovation that we see represented here this week are shaping the future of information technology worldwide. It is important to realize that this information can have a positive impact on our world's developing nations as we use technology to transform our undeveloped world and better their lives.

As many of you know, many of the technologies which enabled electronic commerce to become a reality in the 1990s are based on research initially conducted at universities like the University of Texas. Many of those programs were funded by federal agencies, such as the National Science Foundation and DARPA. Substantial and sustained U.S. investments in research and development during the past 50 years provided breakthroughs which transformed American society and helped the U.S. become the world's dominant economy.

When you use a web browser, send an e-mail, or even use the Internet, you can thank those thinkers and innovators at American universities who have helped develop these technologies that made our world actually a little bit smaller.

Today, the technology developed in university labs translates into multi-billion dollar industries with many of the biggest and most profitable IT companies calling the Lone Star State home. For instance, in 2005 Texas companies exported \$31 billion in computers and electronic products. And the IT industry has been Texas's largest source of exports since 1997.

So you can see how important it is for us to hear from those of you on the front lines of research and development, and from those who are innovative and take those innovations and deliver them to the marketplace.

While we are here this week at the World Congress on Information Technology working with the world's IT community, we must remember that America is still competing in the global marketplace. Nations such as China and India which are relatively new to the IT markets have recognized the importance of innovation to economic growth. They are pouring billions of dollars into their scientific and technological infrastructure, rapidly building their innovation capacity and dramatically increasing their ability to compete with U.S. businesses on the world stage.

As our foreign competitors increase their investment in innovation, we too must do the same. That investment does not just mean dollars and cents, it also means building and maintaining a strong and well educated high tech work force.

A company in my district told me that they have an operational need for 90,000 new engineers during the next ten years, but colleges over the entire United States graduate only about 60,000 per year. That is a problem. It means they will have to export or outsource some of these jobs and import skilled laborers from overseas. In other words, we need more homegrown talent right here in the United States.

Improving math and science education for our kids and providing incentives for our college students to pursue degrees and careers in a technical field are equally important to any financial investment America could make in its quest for technological innovation.

In closing, what we will do here today is listen to you, the experts, and we are eager to hear your thoughts on how to improve research and development and take innovations in the laboratories at places like the University of Texas and bring them to marketplace for America.

Thank you, Mr. Chairman. It is a delight to be here today.  
[The prepared statement of Mr. McCaul follows:]

PREPARED STATEMENT OF REPRESENTATIVE MICHAEL T. MCCAUL

Good afternoon, and thank you for being here today for this special meeting of the House Science Committee. I can't tell you how proud I am of Austin this week as the world turns its eyes to my hometown. And I know that Austin is proud to call itself the Technology Capitol of the World, and the home of the University of Texas, which does so much great work in research and development. Therefore, it is fitting that Austin host this year's World Congress on Information Technology. My thanks to all who have made this event possible.

The companies and the leaders of innovation that we see represented here this week are shaping the future of information technology worldwide. We must also realize that this innovation can have a positive impact on our world's developing nations as we use technology to transform our developed world and better the lives of those in need.

As you know, many of the technologies which enabled electronic commerce to become a reality in the 1990s are based on research initially conducted at universities like the University of Texas. Many of those programs were funded by federal agencies, such as the National Science Foundation and DARPA. Substantial and sustained U.S. investments in research and development during the past 50 years provided these breakthroughs which transformed American society and helped the U.S. become the world's dominant economy.

When you use a web browser, send an e-mail or even use the Internet, you can thank those thinkers and innovators at American universities who have helped develop these great technologies that made our world smaller.

Today, the technology developed in university labs translates into multi-billion dollar industries, with many of the biggest and most profitable IT companies calling the Lone Star State home.

For instance, in 2005, Texas companies exported \$31 billion in computers and electronic products. And the IT industry has been Texas's largest source of exports since 1997.

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Nations such as China and India which are relatively new to the IT markets have recognized the importance of innovation to economic growth. They are pouring billions into their scientific and technological infrastructure, rapidly building their in-

novation capacity and dramatically increasing their ability to compete with U.S. businesses on the world stage.

As our foreign competitors increase their investment in innovation, we too must do the same. That investment does not just mean dollars and cents, it also means building and maintaining a strong and well educated high tech work force.

A company in my district told me that they have an operational need for 90,000 new engineers during the next ten years, but colleges over the entire United States graduate only about 60,000 per year—meaning they will have to export many of those jobs and that is *unacceptable*.

Improving math and science education for our kids and providing incentives for our college students to pursue degrees and careers in a technical field are equally important to any financial investment America could make in its quest for technological innovation.

In closing, what we will do here today is listen carefully to you—the experts in technology and innovation. We are eager to hear your thoughts on how to improve research and development, and take innovations in the laboratories at places like the University of Texas and bring them to marketplace for America and the world to enjoy and appreciate.

We have a great opportunity here today and I know we all plan to make the most of it.

Chairman SMITH. We did not collaborate with each other but I think we put a lot of similarity between our emphasis on education, emphasis on high tech in Austin and India and China as well for good reason. We are all looking in the same direction.

Let me introduce our witnesses. Our first witness is Dr. Peter Freeman, Assistant Director for Computer and Information Science and Engineering at the National Science Foundation. Dr. Freeman was previously at Georgia Institute of Technology as a professor. Dr. Freeman obtained a Bachelor's degree in physics from Rice University, a Master's degree in mathematics from the University of Texas, at Austin, and a doctorate in computer science from Carnegie Mellon University.

Dr. Freeman, you also stated you have a daughter and granddaughter in the audience.

Dr. FREEMAN. Son and granddaughter, yes.

Chairman SMITH. Can we embarrass them and recognize them?

Dr. FREEMAN. That is up to them.

Chairman SMITH. Wave to us if you will. It is nice to have family in the audience. Good.

Our next witness is Mr. Pike Powers, a Partner at Fulbright & Jaworski. Mr. Powers specializes in technology law and is currently the Chairman of the Texas Technology Initiative and a member of Texas Governor Rick Perry's Advisory Committee for the state's emerging technology industry.

Mr. Powers received his Bachelor's degree from Lamar University.

Mr. POWERS. Good choice of name.

Chairman SMITH. Excuse me?

Mr. POWERS. Good choice of name.

Chairman SMITH. I like the name. A Bachelor's degree from Lamar University and a law degree from the University of Texas. Lamar has always been my favorite, or next to favorite university. Mr. Power, I should note, everyone else here has a doctorate. Since you have a J.D., I think we are going to call you doctor as well. Is that all right?

Mr. POWERS. I am willing to accept that designation but only for the purposes of academic discussion.

Chairman SMITH. Our next witness is Dr. Juan Sanchez, the Vice President for Research at the University of Texas at Austin and he holds a Temple Foundation professorship in the Department of Mechanical Engineering. Dr. Sanchez is the author and co-author of over 140 technical publications on a wide range of topics on material science and engineering. He received his Bachelor's degree in physics from the University of Cordoba, Argentina and a Master's and Doctorate degrees in material science from the University of California, Los Angeles.

Our next witness is Dr. Randal Goodall, Director of External Programs at SEMATECH. Dr. Goodall has published numerous papers on R&D collaboration, information technology transition, productivity modeling, and advanced materials analysis. Dr. Goodall received a Bachelor's degree in physics from California Institute of Technology and his doctorate in physics from the University of Oregon.

Dr. Goodall, I hope you don't feel too isolated since you are surrounded by four other witnesses all of whom have ties to the University of Texas.

Dr. GOODALL. My daughter goes to the University of Texas.

Chairman SMITH. Our final witness is Dr. Neil Iscoe, Director of the Office of Technology Commercialization at the University of Texas at Austin. He remains an adjunct professor at UT in the computer sciences department. Dr. Iscoe has been appointed by Governor Perry to serve on the Texas Product Development and Small Business Incubator Advisory Board. Dr. Iscoe has an engineering degree from the University of Wisconsin, a Master's and Doctoral degrees in computer sciences from the University of Texas at Austin.

Once again, welcome to you all. We have your complete testimony and without objection it will be made part of the record. We look forward to your testimony at this point in time and we will start with Dr. Freeman.

**STATEMENT OF DR. PETER A. FREEMAN, ASSISTANT DIRECTOR FOR COMPUTER AND INFORMATION SCIENCE AND ENGINEERING DIRECTORATE (CISE), NATIONAL SCIENCE FOUNDATION**

Dr. FREEMAN. Thank you, Chairman Smith, Congressman McCaul. It is a delight to be here today to speak to you about the topics of this hearing and NSF's contributions to those topics in particular. I want to congratulate you for holding this hearing because I believe that innovation is indeed one of the most important things that our country has to face and information technology is clearly at the core of innovation.

I am one of the seven assistant directors of the National Science Foundation heading the Directorate for Computer and Information Science and Engineering. In my remarks today I will draw upon perspectives I have developed over almost 45 years in the IT field, in industry, academe, and government.

As a Texan, whose career started at Rice, as you have mentioned, and began to mature here in Austin where I did my Master's degree, I consider myself extremely fortunate to have been party to the birth of computer science as a field, both here and at

Carnegie Mellon where I was in the first Ph.D. class. Since then it has been my honor to participate in the transformation of our society that research advances in IT have delivered.

My position today at NSF, which I consider the penultimate of my career, provides me with both a domestic and an international view on IT research and education and its impact on a global scale. I would just note parenthetically I visited India for about two weeks two years ago, China for two weeks last year, and I will be back in China in 10 days. I have seen up close what is going on there.

I will focus my remarks today on four important areas: How NSF investments in information technology research promote innovation in IT and foster the development and commercialization of new applications. How we work with industry to support IT research. How NSF facilitates the use of research it supports in the commercialization of new products. And, finally, how the topics and types of NSF programs in IT research complement investments made both by our sister agencies and by industry research programs.

The importance of IT research in contributing to growth in the economy is indisputable. Recent economic analysis tells us that the remarkable growth in the U.S. economy experienced between 1995 and 2000 was spurred by an increase in productivity enabled almost completely by factors related to IT.

In fact, productivity has increased by an average of over three percent since 1995. This progress is attributed to several factors starting with innovation in IT products, some of which you have mentioned, and equally important, innovation in IT services that allow organizations to engender complementary innovations such as changing business practices, work flow design, decision making structures, interactions with suppliers, and customer relations.

Increasingly, our studies show that investments in IT when accompanied with changes in organization and work practices contribute to an enterprise's productivity growth and its market value. One need look no further than this city of Austin where we are sitting to see how a research university with a major IT focus can have an impact on innovation and economic growth. The presence of UT Austin, just UT in those days as I recall, was important in bringing the Microelectronics and Computer Technology Corporation, MCC, here in the 1980s.

MCC, which was first created to protect U.S. interests in the computer market against foreign consortia, spawned a broad range of start-ups, and attracted high-profile corporations creating IT products that in turn triggered the economic boom that has helped make Austin the dynamic city it is today.

Our nation's strong economic position in IT today is due largely to the fact that starting in the late 1950's we have been making critical investments in fundamental research. Let us look at a particular case in point, one that I am sure everyone in the room is familiar with and has probably used today, Google. In less than a decade Google has revolutionized the way the world accesses information. It has also become a corporate powerhouse.

In the most recent quarter Google reported revenues of over \$2 billion for a single quarter, an astounding 79 percent increase. Google's co-founders, Larry Page and Sergey Brin, while supported

by an NSF-funded project on digital libraries at Stanford University, developed a new approach to online searching that quickly spread to information seekers around the globe.

Google is now widely recognized as the world's largest search engine, an easy-to-use free service, that returns relevant results in just a fraction of a second. Who would have predicted that an investment totaling just thousands of federal research dollars would create a multi-billion dollar a year market and a service that has revolutionized the management of digital information.

As we look to the future, we must ask ourselves what new products and services are out there on the horizon, but are not yet identified for the want of investments in basic research in IT. It is imperative that we make a robust and sustained commitment to the type of investments and education that a decade or more ago produced most of the fundamental concepts that fuel today's IT innovation.

The NSF directorate that I head is now the principal source of federal funding for university-based research in computer science providing 86 percent of total federal support in this area to the Nation's universities which is where most of the fundamental research takes place.

Now more than ever before our nation's future is dependent upon NSF support for fundamental research in IT. The fundamental research that is supported today will be enjoyed by and enhance the quality of life for generations to come. To accelerate the transition of basic research outcomes into technological innovations that seed market competitiveness NSF works closely with its partners in academe and industry. Let me give you some examples.

CISE supports nine IT-oriented Industry/University Cooperative Research Centers (I/UCRCs in Washington speak), a well-established and exceedingly successful program at NSF. I/UCRCs develop long-term relationships among industry, academe, and government. The centers are catalyzed by a small investment from NSF with the majority of research support provided by industry members of those centers.

CISE-supported I/UCRCs focus on areas such as cybersecurity, a grave concern of this committee, e-design manufacturing, search and rescue robotics that contribute to homeland security, and wireless technologies. Each of these centers contributes to the Nation's IT research base and enhances the intellectual capacity of the IT workforce through the integration of research and education, a hallmark of NSF activities, while simultaneously speeding the movement of research outcomes into the marketplace.

NSF also directly invests in IT research in the small business community through our Small Business Innovation Research (SBIR) program. To cite one example, again from here in Texas, we are supporting a research project conducted by a company in Dallas, Potential Research Solutions. They are developing new oil and gas reservoir IT management tools to optimize hydrocarbon recovery. Powerful analytic tools have been developed that provide robust solutions of fluid flow problems with complex, heterogeneous rock properties. This is an industry first, providing the ability to generate a brand new line of desktop hydrocarbon reservoir management tools. In particular, the results of this project will provide

software and services to optimally locate new wells within existing hydrocarbon reservoirs.

Having provided examples of industry-university partnerships, let me turn my attention now to a new activity that promises exceptional opportunities in the future. The directorate that I head, CISE, has recently called upon the broad IT research community, including academe and other private and public organizations, to form what we call a community proxy or representative necessary to guide the development of a major new opportunity in IT, a research facility concept called the Global Environment for Networking Innovations (GENI).

As currently conceived, the GENI facility will provide IT researchers with the tools to explore transformational networking and distributed system architecture and services that will simultaneously advance science and stimulate innovation and economic growth.

We hope GENI will incase the quality and quantity of experimental research outcomes supported by CISE, and to accelerate the transition of these outcomes into products and services to enhance economic competitiveness and secure the Nation's future. In planning for GENI we are working with industry, other U.S. agencies, and international groups. GENI is the first in what we hope will be a series of major efforts to reinforce fundamental research in computer science.

Having provided some examples of the IT research supported by NSF with the significant engagement of the private sector, I would like to speak very briefly in closing to our interactions with colleagues in other federal agencies.

NSF's investments in IT research are made in coordination with our sister agencies. Coordination is enabled through the National Coordination Office for Networking and Information Technology Research and Development which reports to the Office of Science and Technology Policy and the National Science and Technology Council (NSTC).

NSF plays a leadership role in all of those activities. I personally co-chair the over-arching Steering Committee and members of my staff co-chair all of the subcommittees. As the focal point for coordination and policy development for the interagency federal IT research and development program, NITRD activities foster collaboration among federal agencies, university researchers, industry, and other members of the IT community.

For example, NSF and the Departments of Energy and Defense have been making coordinated investments in fundamental research essential to the development of high-performance computing software and tools.

In my testimony today, I have tried to provide examples of the ways in which NSF works with its partners in the private sector and in government to stimulate economic prosperity. This committee clearly recognizes the importance of innovation to the vitality of our economy. The President's American Competitiveness Initiative (ACI) also quite rightly points out that our Nation's continued ability to lead in research is essential to maintaining a competitive edge in a global economy.

With robust, sustained support for fundamental research in both the executive and legislative branches, we have a unique opportunity to strengthen our nation's investments in that research and education, thereby securing our nation's economic future for many years to come.

I look forward to your questions.

[The prepared statement of Dr. Freeman follows:]

PREPARED STATEMENT OF PETER A. FREEMAN

Good afternoon, Mr. Chairman and Members of the Committee. I am delighted to have the opportunity to talk with you today about research partnerships in information technology and the contributions of NSF-supported research to U.S. competitiveness, both now and in the future.

I am Peter Freeman, Assistant Director of the National Science Foundation for Computer and Information Science and Engineering, and I head one of the seven directorates of NSF. In my remarks today, I will draw upon perspectives I have developed over my forty-five years in the IT field—in industry, academe, and government. As a Texan, that career started at Rice and began to mature here in Austin where I did my Master's degree. I consider myself extremely fortunate to have been party to the birth of computer science as a field—both here and at Carnegie Mellon University where I was in the first entering Ph.D. class. Since then, I have taken great pleasure in participating in the transformation of our society that research advances in IT have delivered. My position today at NSF provides me with both a domestic and an international vista on IT research and education, and its impact on a global scale.

I will focus my remarks today on four important areas: How NSF investments in information technology research promote innovation in IT and foster the development and commercialization of new applications. How NSF works with industry to support IT research. How NSF facilitates the use of research it supports in the commercialization of new products. And finally, how the topics and types of NSF programs in IT research complement investments made both by other federal agencies and by industry research programs.

The importance of IT research in contributing to growth in the economy is indisputable. Recent economic analysis tells us that the remarkable growth the U.S. economy experienced between 1995 and 2000 was spurred by an increase in productivity enabled almost completely by factors related to IT. In fact, productivity in the U.S. has increased by an average of over 3.1 percent a year since 1995. This progress is attributed to several factors: innovation in IT products, and, equally importantly, innovation in IT services that allow organizations to engender complementary innovations, such as changing business processes, work flow design, decision-making structures, interactions with suppliers, and customer relations. Increasingly, studies show that investments in IT AND changes in organization and work practices contribute to an enterprise's productivity growth and in the commercial sector, its market value.

One need look no further than the city of Austin to see how a research university with a major IT focus can have an impact on innovation and economic growth. The presence of the University of Texas at Austin was important in bringing the Microelectronics and Computer Technology Corporation (MCC) here in the 1980's. The MCC, first created to protect US interests in the computer market against foreign consortia, spawned a broad range of start-ups and attracted high-profile corporations creating IT products that triggered the economic boom that has helped make Austin the dynamic city it is today.

Our nation's strong economic position in IT today is due largely to the fact that starting in the late 1950's we have been making critical investments in fundamental research. Let's look at a case in point—one I am sure you are familiar with—Google. In less than a decade, Google has revolutionized the way the world accesses information. It has also become a corporate powerhouse. On March 31, 2006, Google reported revenues of \$2.25 billion for the quarter ended March 31, 2006, an astounding increase of 79 percent compared to the first quarter of 2005. Google's co-founders, Larry Page and Sergey Brin, while supported by an NSF-funded project on digital libraries at Stanford University, developed a new approach to online searching that quickly spread to information seekers around the globe. Google is now widely recognized as the world's largest search engine—an easy-to-use free service that returns relevant results in just a fraction of a second. Who would have predicted that an investment totaling just thousands of federal research dollars would create a

multi-billion dollar a year market and a service that has revolutionized the management of digital information.

As we look to the future, we must ask ourselves—what new products and services are out there on the horizon, but are not yet identified for the want of investments in basic research in IT. It is imperative that we make a robust and sustained commitment to the type of investments that a decade and more ago produced most of the fundamental concepts that fuel today's IT innovations.

NSF's CISE directorate is now the principal source of federal funding for university-based basic research in computer science, providing 86 percent of total federal support in this area. Now more than ever before, our nation's future is dependent upon NSF's support for fundamental research in IT. The fundamental research that is supported today will be enjoyed by and enhance the quality of life for generations to come.

To accelerate the transition of basic research outcomes into technological innovations that seed market competitiveness, NSF works closely with its partners in academe and industry.

For example, CISE supports nine IT-oriented Industry/University Cooperative Research Centers (I/UCRCs), a well-established and exceedingly successful program at NSF. I/UCRCs develop long-term partnerships among industry, academe, and government. The centers are catalyzed by a small investment from NSF, with the majority of research support provided by industry center members. CISE-supported I/UCRC's focus on areas such as cyber security, a grave concern of this committee, e-design manufacturing, search and rescue robotics that contribute to homeland security, and wireless technologies. Each of these I/UCRC's contributes to the Nation's IT research base and enhances the intellectual capacity of the IT workforce through the integration of research and education, while simultaneously speeding the movement of research outcomes into the marketplace.

NSF also directly invests in IT research in the small business community, through the agency's Small Business Innovation Research (SBIR) program. To cite one example right here in Texas, NSF is supporting a research project conducted by a company in Dallas—Potential Research Solutions. They are developing new oil and gas reservoir IT management tools to optimize hydrocarbon recovery. Powerful analytic tools have been developed that provide robust solutions of fluid flow problems with complex, heterogeneous rock properties. This is an industry first, providing the ability to generate a brand new line of desktop hydrocarbon reservoir management tools. In particular, the results of this project will provide software and services to optimally locate new wells within existing hydrocarbon reservoirs.

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CISE has recently called upon the broad IT research community, including academe and other private and public organizations, to form a community proxy necessary to guide the development of a major new opportunity in IT—a research facility concept called the Global Environment for Networking Innovations (GENI). As currently conceived, the GENI facility will provide IT researchers with the tools to explore transformational networking and distributed system architectures and services that will simultaneously advance science and stimulate innovation and economic growth. We hope GENI will increase the quality and quantity of experimental research outcomes supported by CISE, and to accelerate the transition of these outcomes into products and services to enhance economic competitiveness and secure the Nation's future. In planning for GENI, we are working with industry, other U.S. agencies, and international groups. GENI is the first in what we hope will be a series of major efforts to reinforce fundamental research at scale in the computer science field.

Having provided some examples of the IT research supported by NSF with the significant engagement of the private sector, I'd like to speak briefly to our interactions with colleagues in other federal agencies.

NSF's investments in IT research are made in coordination with our sister agencies. Coordination is enabled through the National Coordination Office for Networking and Information Technology Research and Development which reports to the Office of Science and Technology Policy and the National Science and Technology Council (NSTC). NSF plays a leadership role in NITRD activities, and I personally co-chair the NSTC's interagency NITRD subcommittee. As the focal point for coordination and policy development for the interagency federal IT research and development program, NITRD activities foster collaboration among federal agencies, university researchers, industry, and other members of the IT community. For example, NSF and the Departments of Energy and Defense have been making coordinated investments in fundamental research essential to the development of high-

performance computing software and tools. A study currently being conducted by the Council on Competitiveness with NSF and DOE support identifies five grand challenges in the oil and gas, chemical, and auto industries that provide concrete and quantifiable assessments of the economic benefits of high-performance computing-driven innovation, describing some of the “what if” questions that high-performance computing can address and the new opportunities for economic growth it can create. This is but one area of many in which agencies are working together to add value to the cumulative federal investment in IT research.

In my testimony today, I’ve tried to provide examples of the ways in which NSF works with its partners in the private sector and in government to stimulate economic prosperity. This committee clearly recognizes the importance of innovation to the vitality of our economy. The President’s American Competitiveness Initiative (ACI) also quite rightly points out that our nation’s continued ability to lead in research is essential to maintaining a competitive edge in a global economy. With robust, sustained support for fundamental research in both the executive and legislative branches, we have a unique opportunity to strengthen our nation’s investments in fundamental IT research, thereby securing our nation’s economic future for many decades to come.

#### BIOGRAPHY FOR PETER A. FREEMAN

Peter A. Freeman became Assistant Director for the Computer and Information Science and Engineering Directorate (CISE) on May 6, 2002.

Dr. Freeman was previously at Georgia Institute of Technology as professor and founding Dean of the College of Computing since 1990. He served in that capacity as the John P. Imlay, Jr. Dean of Computing, holding the first endowed Dean’s Chair at Georgia Tech. He also served as CIO for the campus for three years. In addition, as a general officer of the campus, he was heavily involved in planning and implementing a wide range of activities for the campus including a successful \$700M capital campaign and the Yamacraw Economic Development Mission. He was in charge of the FutureNet Project, part of the campus technology preparations for the 1996 Olympic Village, that resulted in a very high-performance and broad campus network. In 1998, he chaired the Sam Nunn NationsBank Policy Forum on Information Security which led to the creation of the Georgia Tech Information Security Center, one of the first comprehensive centers in the country focused on information security.

During 1989–90 Dr. Freeman was Visiting Distinguished Professor of Information Technology at George Mason University in Fairfax, Virginia, and from 1987 to 1989 he served as Division Director for Computer and Computation Research at the National Science Foundation. He served on the faculty of the Department of Information and Computer Science at the University of California, Irvine, for almost twenty years before coming to Georgia Tech.

He co-authored *The Supply of Information Technology Workers in the United States* (CRA, 1999) and authored *Software Perspectives: The System is the Message* (Addison Wesley, 1987), *Software Systems Principles* (SRA, 1975), and numerous technical papers. In addition, he edited or co-edited four books including, *Software Reusability* (IEEE Computer Society, 1987), and *Software Design Techniques*, 4th edition (IEEE Press, 1983). He was the founding editor of the McGraw-Hill Series in Software Engineering and Technology, has served on several editorial boards and numerous program committees, and was an active consultant to industry, academia, and government.

Dr. Freeman was a member of the Board of Directors of the Computing Research Association (1988–2002), serving as Vice-Chair and Chair of the Government Affairs Committee. He was a member of select review committees of the IRS and FAA Air Traffic Control modernization efforts, and has served on a variety of national and regional committees. While at NSF, he helped formulate the High-Performance Computing and Communications Initiative of the Federal Government.

Dr. Freeman is a Fellow of the IEEE (Institute for Electrical and Electronics Engineers), AAAS (American Association for the Advancement of Science), and the ACM (Association for Computing Machinery). He received his Ph.D. in computer science from Carnegie-Mellon University in 1970, his M.A. in mathematics and psychology from the University of Texas at Austin in 1965, and his B.S. in physics from Rice University in 1963. His research and technical expertise has focused on software systems and their creation. His earliest work (1961–63) involved developing advanced scientific applications in the days before there were operating systems and other support software. This led him to design and build one of the earliest interactive time-sharing operating systems (1964) and ultimately to early work applying

artificial intelligence to the design process for software (1965–75). This culminated with the publication of his first book, *Software System Principles* (SRA, 1975).

After a short stint teaching overseas for the United Nations, he focused his work on software engineering, ultimately being recognized for this early work by being elected a Fellow of the IEEE. Along with Prof. A.I. Wasserman, he developed one of the first software design courses (taken by thousands of industry practitioners) and published a highly popular text that served as a first introduction to software engineering. His research during this period focused on reusable software, especially using formal transformation systems. That work has resulted in several startup companies.

Since 1987 when he was “loaned” by the University of California to the National Science Foundation, he has focused his attention on national policy and local action intended to advance the field of computing. In addition to his many activities as Dean at Georgia Tech, he headed an NSF-funded national study of the IT worker shortage (<http://www.cra.org/reports/wits/cra.wits.html>), started an active group for Deans of IT& Computing, and published several papers relative to future directions of the field.

Chairman SMITH. Thank you, Dr. Freeman.

**STATEMENT OF MR. PIKE POWERS, PARTNER AT FULBRIGHT & JAWORSKI L.L.P.; CHAIRMAN OF THE TEXAS TECHNOLOGY INITIATIVE**

Mr. POWERS. Thank you, Dr. Smith. It is a genuine pleasure to be here today. I have filed, along with the other speakers, some written testimony eight pages in length. What I would like to do, Mr. Chairman, is hit some Power Points and cover everything.

Suffice it to say that out of all my colleagues on this dias, all endorse and subscribe, just as apparently the two of you do, to the tenets of Tom Friedman’s incisive book, *“The World is Flat”* and the report by the National Academies, *“Rising Above the Gathering Storm,”* and all that went with that. Ultimately, of course, the development of President Bush’s American Competitiveness Initiative so lest there be any doubt about where I am.

I think personally everybody I know in Austin, Texas, that works on these kind of issues stand to wholeheartedly and enthusiastically endorse President Bush’s initiative. We know that this committee has a lot to do and has a wide degree of responsibility associated with the implementation of that package or program.

We endorse what Norman Augustine did with *“Rising Above the Gathering Storm,”* and, as a matter of fact, at least three Texans are members of the 20-member commission, Lee Raymond and Peter O’Donnell, and a fellow named Bob Gates from Texas A&M. Congressman McCaul, I think you know him. Suffice it to say that those findings and those recommendations are crucial to this nation’s future.

I would echo your opening statements, Chairman Smith, dealing with education. In my paper, or document, on page one I describe the recent findings of National Geographic in conjunction with Roper Public Affairs. I hope everybody in the room has access to the paper on 18- to 24-year-olds. Shockingly and stunningly 63 percent cannot find Iraq or Saudi Arabia on a map of the Middle East; 37 percent could not identify Louisiana despite the fact that they had a hurricane recently, and so on and so forth. The interviews lasted an average of 27 minutes each so they were not short, snappy ones but rather protracted.

National Geographic said in the executive summary accompanying the study, “Taken together these results suggest that

young people in the United States are unprepared for an increasingly global future.” I guess if permitted the luxury of a quote or comment at this point, we might cite James Lovell’s famous quote during the Apollo XIII, “America, we have a problem.” If this topical study is any indication of the state and quality of the American education, then yes, we have a problem.

I go on there to say we must deal with education issues. I think that is an agreed-upon principle here for today’s meeting, in addition to the reports that I endorsed previously. To make a few remarks where I would like perhaps to put a little bit more weight. Recently Chancellor Yudof of the University of Texas System, the offices of which are completely in your district, Congressman Smith, in downtown Austin, as you well know, recently convened a panel of business people who have dealt with everything from research issues to tech transfer to finding available capital formation for new ventures. There were a lot of comments at those meetings, just as we have all heard around the country, but on page two of my testimony at the top of the page it emphasizes some things that I think bear discussion and further investigation by your committee in no particular order of relevance.

- License income is very much below what it can be for these universities;
- Industry says that working with the university community is difficult, to say the least. (This is not intended to be a set of comments from my colleagues to my left but they deal with me virtually every day and this is what was reflected from a group discussion or two or three.)
  - Universities do not do an adequate job of what can be called “internal prospecting;”
  - Early-stage seed, angel, and venture capital funding has essentially disappeared and detached from university-based commercialization;
  - No one is addressing the full spectrum of what it takes to commercialize new technology;
    - Universities do not have a good handle on the metrics of successful technology transfer.
    - There is a strong need for universities to have a rallying point for better and more lasting connection with the capital community; and
    - Too many research universities have not constructed viable reward systems for innovative faculty.

At the bottom of page two I talk about Karin Rivard, Assistant Director and counsel for MIT’s Technology Licensing Program, she makes four statements that are on page two about myths that we all have to come to grips with and keep our eye on the ball. These are the myths.

- Royalties are already a significant source of revenue for universities;
- Expect a quick return on technology transfer investment by the universities;

- Companies are eager to accept new technologies from universities; and
- One should simply broadcast the availability of technology for licensing in order for that to occur.

She points out after referring to the myths that the real primary objective should be successful technology transfer, not the larger goals of maximizing income alone.

On page three I did want to emphasize and make reference to a couple of comments in the middle of the page and I will talk more about this later with reference to Center for Economic Development Innovation and Commercialization for the Big 12 Athletic Conference that some of my colleagues are here in the room today and I will introduce them in a minute.

We have learned that significantly the federal program should strengthen multi-disciplinary, multi-state, multi-institution development efforts and help bring universities, small companies, and large companies to develop new technologies needed for successful ventures.

I specifically refer to and describe four programs that I think are mandatory for your support or continued involvement: Partners for Innovation, National Science Foundation, Dr. Freeman; the Rural Policy Research Institute (RUPRI) funded in part by the Department of Agriculture; and Department of Commerce and the EDA program. Last, but not least, the Advanced Technology Program at the National Institute of Standards and Technology, otherwise known as NIST.

At the bottom of page three I make some comments about the ATP program which was started in the '90s by then President Clinton and has been controversial given the current political lay of the land in Washington, D.C. which the two of you reflect. While it has been controversial the solid evidence seems to indicate that ATP is a proven tool.

Under the leadership of Gordon Moore of Intel of the famous Moore's Law, developing technologies within prescribed periods of a semiconductor world they concluded that it does work, that it is a solid program and in some form it should be continued. I am here today to support that proposition.

Moving to page four, I once again endorse the comments that Chairman Augustine of *"Rising Above the Gathering Storm."* You posed some questions in your invitation to appear, and we do appreciate the invitation, that I have attempted to answer in questions one, two, and three. Question number four was one that I did want to make a comment or two about.

What are the barriers to use of university results in commercialization of new information technology products. You will hear this over and over and over again. I don't think it is anything new or it is not a big secret. In the middle of that paragraph, our country is short on support of the middle stage where the theoretical/conceptual ideas of a university are turned into prototypes. Often called the "Valley of Death," this is where federal innovation award programs such as SBIR and ATP could provide a much-needed bridge across that valley. So I commend that to you.

Turning to page six, my business partner Ron Kessler is here in the room along with a colleague, Cliff Drummond who has been working with me over the last 18 months to develop and put into place a Center for Economic Development Innovation and Commercialization.

You will see on page six the Big 12 is Baylor University at Waco; University of Colorado at Boulder; Iowa State at Ames; University of Kansas at Lawrence; Kansas State University at Manhattan; University of Missouri, Columbia; University of Nebraska, Lincoln; University of Oklahoma at Norman; Oklahoma State at Stillwater; University of Texas at Austin; Texas A&M at College Station, and Texas Tech in Lubbock.

We have created this center over the last 18 months and have worked closely with the chancellors and presidents of virtually every one of these universities in some degree of detail including my colleagues Dr. Sanchez and Dr. Iscoe. They have been very cooperative and have very supportive. We have developed a large body of information and received well over 400 extensive briefings on R&D activities throughout the seven-state region.

We have heard university leadership of these 12 institutes, among others, that they need help, lots of help in globalizing the marketplace. The commercialization business tends to be rather parochial. We have seen and they have seen first-rate R&D. These 12 universities currently are conducting in excess of \$3 billion of R&D activities from all funding sources. There are jewels within these research establishments that have been intensively developed and have demonstrated both technical and market merit.

The purpose of the Big 12 CEDIC is to expand, foster, and facilitate and encourage and nurture in the processes of commercialization, innovation, entrepreneurship, research collaboration, and technology transfer activities from the member universities and the private sector wherever and whenever appropriate. CEDIC will connect identified programs to the private sector. We fully realize and appreciate that successfully commercializing new products and technology is not as simple as I have made it sound.

It requires both specialized skills not normally in abundance within academia, as well as an understanding of the limits of academic research and the rigors of the marketplace. It also requires a deep working knowledge of the capital community as well as the models of successful companies throughout the broad spectrum of commerce.

We believe that it is an innovative and novel approach and we have had conversations with people up and down the research, funding, and commercialization landscape who agree with that statement. At the end of the day the gap-bridging organizations like CEDIC have to know, understand, and work with the very different cultures of academics and commerce. These activities are very difficult and not for the risk-averse.

What I want to say to you sort of as I wrap up and close, the information there on page seven about what we are trying to accomplish is really kind of the underlying set of values that we ought to encourage in commerce with the state and federal agencies working on these activities within our universities. It is about

connecting, not just throwing people together. It is about thinking regionally. It is about relationships, not just “good ideas.”

It is about technical competency by the right members of expert panels covering all the right areas of science and engineering. It is about financial support for competent groups like CEDIC to successfully fill the gap between university research and commercialization. It is about university leadership. By the way, the 12 presidents of the Big 12 have been receiving copies of my drafts as we have gone along.

While this is certainly not anything that they have condoned or endorsed in terms of my appearance and what I am saying here today, they have all seen every draft of what I have been doing so we have been trying to build a degree of relationships that focuses on your activities as well. I’ll come back to that as I close in just a minute.

The paradigm dramatically changed and a conscious decision to turn to industry to come alongside them in areas where academia can benefit from outside help. It is about multiple strategies to bridge the gap between university lab-to-market technology. It is about increasing university IP revenue. It is about business as usual no longer being the usual.

We need new types of organizations to bring to the table unique skills which when combined with new approaches by university leadership have the best change to produce successful commercialization and technology transfer of university research. Everyone benefits, inventors, faculty, students, universities, business, government, consumers, customers, and ultimately the economy.

We are putting together at some stage, and Congressman McCaul has had very early conversations with me about assembling a congressional caucus, Chairman Smith, that would have 54 Congressmen from seven states, 14 U.S. Senators and seven Governors to stand tall for concepts on a bipartisan basis that can be agreed upon that are very important in this area. We would hope that both of you would consider participating in that endeavor.

Let me close and say thanks to both of you for a job well done. I have had the pleasure and privilege of working with both of you over a long period of time and I salute you. You do a terrific job. I am pleased and proud to have you as my Congressman, Lamar. Michael and I have become very close friends. We appreciate what the two of you do and know how hard it is in Washington. That is the doctrine I have and I just want to say thanks for all of us.

Let me close and wrap up by saying my buddy, friend, colleagues down at the table here, Randy Goodall, who has been kind of our resident genius in crafting the Texas Technology Initiative has got some remarks. I have seen them and heard them because I have lived with them for the last three or four years. I close by saying that I endorse his testimony.

I think it is more than just endorsing his testimony. What he has put together has been a framework for the future of the state of Texas. It has led to the implementation and the development of the Enterprise Fund which led to the development and implementation of the Emerging Technology Fund. We have just begun on a series of other initiatives that will hopefully help set the stage in the future of the State of Texas.

We need your help actively, gentlemen, to participate in some of those projects. I just wanted to close by saying I think Randy Goodall will offer you a real true platform for the future that you can participate in. Thanks for having us here today.

[The prepared statement of Mr. Powers follows:]

PREPARED STATEMENT OF PIKE POWERS

Many of the witnesses—myself included—who are testifying in these hearings will refer to Tom Friedman’s incisive book, *“The World is Flat”* or the recent report by the National Academies, *“Rising Above the Gathering Storm.”* Along with the previous work by your committee, Mr. Chairman, you have seen a great deal of material and have received a host of thoughtful recommendations. I ask your indulgence to add to that pile just a little bit.

Perhaps another study should be added to the record. Earlier this week, National Geographic, in conjunction with Roper Public Affairs, released their 2006 survey of 18–24-year-old young American adults. Some of the more salient results are stunning:

- 63 percent could not find Iraq or Saudi Arabia on a map of the Middle East;
- 37 percent could not identify Louisiana, 48 percent could not find Mississippi, 50 percent failed to pinpoint New York State;
- only 35 percent correctly choose Pakistan from four possible choices as the country hit by a catastrophic earthquake in October 2005;
- only 18 percent know that Mandarin Chinese is the most widely spoken native language in the world;
- when asked which of four countries has a majority of Muslim residents, only 25 percent correctly identified Indonesia.

By the way, these interviews lasted an average of 27 minutes each! As National Geographic said in the executive summary accompanying the study, “Taken together, these results suggest that young people in the United States are unprepared for an increasingly global future.”

If I may be permitted a slight variation of astronaut James Lovell’s famous quote during the Apollo XIII mission, “America, we have a problem.” If this topical study is any indication of the state and quality of American education, then yes, we have a problem.

Mr. Chairman, among the questions you asked us to address deals with “what areas of research and what type of programs should government support to maintain U.S. competitiveness?” While the Science Committee is focused on innovation and commercialization, there is a clear message here for the Congress and the whole country that we must do a better job in education—all across the board.

The Chancellor of the University of Texas System, Mark Yudof, recently convened a panel of business and community leaders to address how Texas and its research universities can best optimize research and technology transfer. Among the comments he heard were a number of observations based on the hard-earned experience of business people not directly involved in the awesome task of running our nation’s outstanding research universities. These comments have very likely been heard at similar discussions around the country.

- Royalty and license income is very much below what it can be for these universities;
- Industry says that working with the university community is difficult, to say the least;
- Universities do not do an adequate job of what can be called “internal prospecting;”
- Early-stage seed, angel, and venture capital funding has essentially disappeared and detached from university-based commercialization;
- No one is addressing the full spectrum of what it takes to commercialize new technology;
- Universities do not have a good handle on the metrics of successful technology transfer;
- There is a strong need for universities to have a rallying point for better and more lasting connection with the capital community;
- Too many research universities have not constructed viable reward systems for innovative faculty.

From my own experience working with and listening to a great many presidents and chancellors of research universities, I believe it is fair to say they realize the great, inherent value of successfully commercializing new technology coming out of their research establishments. It's of great value to their mission of teaching and education—of great value to our students and to excellence within faculties, and—of great value to local, regional, and national economies.

Last summer, Karin Rivard, Assistant Director and counsel for MIT's Technology Licensing Office, gave a brilliant and clear-headed presentation on the commercialization of university technology.

Some of the *myths* that academia, the government, and the public will have to come to terms with include:

- Royalties are already a significant source of revenue for universities;
- Expect a quick return on technology transfer investment by the universities;
- Companies are eager to accept new technologies from universities;
- One should simply broadcast the availability of technology for licensing.

She concludes that the primary objective is successful technology transfer, not solely the larger goals of maximizing income.

I endorse her insights. We must keep our eye on the ball before us. What all the principal players are after—whether it's academia, the government, business, or the capital investment community—is to find those jewels of research that are mature enough and with clear advantages—and then to help successfully move them from the lab to the marketplace.

One of the key goals of your committee is to examine new ways in which “government investment in research that promotes innovation and fosters the development and commercialization of new applications” can help not only the economic vitality of this country, but that also meaningfully contributes to a healthier set of global relationships.

I know that your committee has looked closely at the advisability of the Congress establishing an ARPA-like agency within the Department of Energy. I know your committee has taken a keen interest in the Nation paying greater attention devoted to enhancing science and math education in the U.S. And, I also know that the Committee had a significant role in helping develop the President's “American Competitiveness Initiative (the ACI).”

From my vantage point of an active career in the law, in economic development, in supporting government's role in innovation, and in community affairs, I urge you and your colleagues in both bodies and on both sides of the aisle to commit meaningful investment in the principal tenets of the ACI:

- Doubling the federal commitment to the most critical basic research programs in the physical sciences over the next 10 years;
- Encouraging the expansion of a favorable environment for additional private-sector investment in innovation;
- Improving the quality of education to provide American children with a strong foundation in math and science;
- Supporting universities that provide world-class education and research opportunities;
- Providing job training that affords more workers and manufacturers the opportunity to improve their skills and better compete in the 21st century;
- Attracting and retaining the best and brightest to enhance entrepreneurship, competitiveness, and job creation in America by supporting comprehensive immigration reform; and
- Fostering a business environment that encourages entrepreneurship and protects intellectual property.

I would encourage the Committee—working in conjunction with your colleagues in appropriations and on other relevant committees—to work for and support those federal programs that strengthen multi-disciplinary, multi-state development efforts and help bring universities, small companies, and large companies together to develop new technologies needed for future U.S. growth and competitiveness. Let me recommend four examples such as the very successful Partners for Innovation (PFI) program within the National Science Foundation, the various centers within the Rural Policy Research Institute (RUPRI) funded in part by the Department of Agriculture, programs at the Department of Commerce such as the Economic Development Administration, the Advanced Technology Program (ATP) at the National Institute of Standards and Technology (NIST).

I know the Advanced Technology Program has sometimes been controversial, but that dates from the politics of the 1990s. In the post-9/11 environment, and with the striking emergence of China and India into the global economy, we are in a very different world, a world in which we need every tool we have. The good news is that ATP is a proven tool. Under the leadership of Intel's Gordon Moore, the National Academies of Science reviewed the operation of the ATP. Their report, *The Advanced Technology Program: Assessing Outcomes*, concluded that the program works. The National Academies found that ATP is meeting its legislative goals and is making possible advances in fuel cells, breast cancer diagnostics, and nanotechnology that will enhance the future welfare and wealth of the American people.

As discussions go ahead on what we might do to set up new institutions to develop new energy technologies, we should not abandon programs that are already working. Accordingly, the ATP budget should be restored and I would suggest that the program be tasked with doing work for other agencies to help accelerated the transfer of university and laboratory technologies into the marketplace.

I was greatly encouraged by your committee's hearing last October on the National Academies' report entitled: *"Rising Above the Gathering Storm."* The Chairman of that study, Norm Augustine, distinguished retired Chairman and CEO of Lockheed Martin, provided his committee's summary of where things now stand—quite apart from all the shortcomings that have been identified.

He said, "the enigma is that in spite of all these factors, America seems to be doing quite well just now. Our nation has the highest R&D investment intensity in the world. We have indisputably the finest research universities in the world. California alone has more venture capital than any nation in the world other than the US. Two million jobs were created in America in the last year alone, and citizens of other nations continue to invest their savings in America at a remarkable rate." He concluded, "Total household net worth (in the U.S.) is now approaching \$50 trillion."

Specific answers to your questions, as posed, are as follows:

**1. How does government investment in information technology research promote innovation in IT and foster the development and commercialization of new applications?**

Government investment in IT research, either at the early research stage (e.g., 10 years out) or at the commercialization stage (two years out), is important. However, since companies can rarely fund high-risk, visionary research, it is most important that the government provide support for that basic research either in universities or in government research labs.

Fund challenge grants that are targeted on high priority needs of U.S. economy (e.g., Alternative Energy Initiative and Health Care Policy).

**2. What role does university research play in innovation in information technology?**

Most industry-based research focuses on near-term (one to five years out) technical challenges related to their existing product line and/or economic niche. (This is often called "applied research" or "development".) In contrast, universities, for the most part, focus on IT challenges that are ten or more years away from commercialization. (This type of research is often defined as "basic research".) Because of this freedom to explore ideas in new, uncharted territory, university research can identify completely new software or hardware IT principles that can open the possibilities for new economic sectors based on new IT products.

Hence, university-based research is exceedingly important as an engine for commercialization of products that will impact the economy a decade or more in the future. It is this futuristic research, or basic research, in the universities that spawns the new companies of tomorrow.

Prioritize research that leads to convergence between IT-, nano- and bio-science.

**3. How do companies balance support for research conducted within the company and research performed at universities?**

Companies, if they support research at universities, typically support applied research that addresses relatively near-term challenges that can be uniquely solved by a university due to the university's specialized capabilities. In the U.S., both our companies and our universities have different niche capabilities. It is the universities that are focused on applied research that have the best alignment between their capabilities and a company's applied research needs.

Peer review raw laboratory science for its market viability.

"Open Innovation" between investigators and other public, private research labs.

Create additional tax incentives for private sector R&D investment, especially alongside university research.

**4. What are the barriers to use of university results in commercialization of new information technology products?**

To me, the biggest barrier is that the U.S. does not have sufficient investment funds (either public or private) to take the university research results that are typically at the theoretical or conceptual stage to a “proof of concept” and prototype product stage. Private funding from venture capital or existing companies is easy to obtain at the prototype stage. However, our country is short on support of the middle stage where the theoretical/conceptual ideas of a university are turned into prototypes. Often called the “Valley of Death,” this is where federal innovation award programs like SBIR and ATP provide a much needed bridge across the valley. The interesting thing is that the awards not only provide capital at a critical phase in the development of new technologies, the awards also attract private sector investment, what some analysts have called a “halo” effect, meaning that a company that has a technology that can win a competitive award may well be worth private sector investment as well.

As noted, it is very important that we augment our investments in physics and chemistry and other disciplines, but at the same time, we need to ensure that the innovation chain remains unbroken, with the necessary incentives provided to bring the results of that research forward into the market. Other countries have recognized the strengths of programs like ATP and SBIR. Many of them are in fact emulating these programs or, like Finland and Taiwan, already have similar programs, often with proportionally greater funding.

I recommend that the U.S. create a mechanism to fund early-stage “hardening” of raw university technology.

As you and your committee well know, Norm Augustine’s National Academies’ committee made four broad recommendations as the basis of a “prosperity initiative” which included 20 specific actions required to make those broad recommendations a reality. If the Congress and this nation is committed to innovation and to international leadership, each of these 20 recommendations must be adopted and supported.

Ron Kessler, my business partner, and I (Powers & Kessler L.L.C.) have developed, with the Big 12 Athletic Conference,

Baylor University  
 University of Colorado  
 Iowa State University  
 The University of Kansas  
 Kansas State University  
 University of Missouri–Columbia  
 University of Nebraska–Lincoln  
 University of Oklahoma  
 Oklahoma State University  
 University of Texas at Austin  
 Texas A&M University  
 Texas Tech University

the Center for Economic Development Innovation and Commercialization (or CEDIC for short). During the concept-validation phase of our work over the past 18 months, we have worked closely with each university president and chancellor, with all the provosts and vice presidents for research, with the deans of each of the major colleges, and with a very large number of key individual faculty investigators. We have received well over 400 extensive briefings on R&D activities throughout the seven-state region of the conference.

We have heard university leadership say they need help—lots of help. In a globalizing marketplace, the commercialization business tends to be rather parochial. We have seen first-rate R&D. These 12 universities currently are conducting in excess of \$3 billion R&D activities from all funding sources. There are jewels within these research establishments that have been intensively developed and have demonstrated both technical and market merit.

The purpose of the Big XII CEDIC is to expand, foster, and facilitate the processes of commercialization, innovation, entrepreneurship, research collaboration, and technology transfer activities from the member universities to the private sector where appropriate. CEDIC will connect identified programs to the private sector. CEDIC

contemplates generation of additional financial and intellectual resources for the universities and the stimulation of the larger economic community. CEDIC will serve as the key focal point by providing improved access to knowledge capital, leadership capital, and financial capital on behalf of the twelve member universities.

We fully realize and appreciate that successfully commercializing new products and technology is not as simple as perhaps I have made it sound. It requires both specialized skills not normally in abundance within academia, as well as an understanding of the limits of academic research and the rigors of the marketplace. It also requires a deep working knowledge of the capital community as well as the models of successful companies throughout the broad spectrum of commerce.

CEDIC is an innovative and novel approach.

At the end of the day, gap-bridging organizations—like CEDIC—have to know, understand, and work with the very different cultures of academia and commerce. These activities are very difficult, and not for the risk-averse.

While CEDIC faces the same challenges as do the investment and capital communities, its spectrum is considerably larger and much more complex. Typically, investors specialize in certain industries, types of deals, and stages of development. CEDIC's charter is more broadly addressed to a much larger gamut of possibilities. CEDIC is vigorously—

- about *connecting*, not just throwing some folks together;
- about thinking regionally;
- about *relationships*, not just “good ideas;”
- about *technical competency*, by the right members of expert panels covering all the right areas of science and engineering;
- about *financial support* for competent groups like CEDIC to successfully fill the gap between university research and commercialization;
- about *university leadership* realizing that their paradigms have dramatically changed, and a conscious decision to turn to industry to come alongside them in areas where academia can benefit from outside help;
- about *multiple strategies to bridge the gap* between university lab-to-market technology;
- about *increasing university IP revenue*;
- about *business-as-usual* no longer being the usual. New types of organizations—like CEDIC—bring to the table unique skills which, when combined with new approaches by university leadership, have the best chance to produce successful commercialization and technology transfer of university research. Everyone benefits—inventors, faculty, students, universities, business, government, consumers and customers, and the economy.

In closing, I would underscore the testimony of Dr. Randy Goodall by emphasizing:

1. The semiconductor industry has created a collaborative model/platform for research, development, and commercialization, consisting of a well-defined pipeline and roadmap—that is needed/can be used by the whole IT sector (communications, software, elec. systems, semiconductors).
2. The need to understand and plan for the convergence of technologies—necessary to be able to afford costly R&D.
3. The importance of awareness and adoption/use of the model (pipeline, roadmap, etc.) in emerging, nascent technologies.
4. The importance of preserving and capitalizing on our relative strengths/resources as innovation engine, technology developers. Don't let what we have slip away.

#### BIOGRAPHY FOR PIKE POWERS

##### **Experience**

A partner since 1978, Pike Powers is Partner-in-Charge of Fulbright & Jaworski L.L.P.'s Austin office. Mr. Powers was Executive Assistant to Governor Mark White in 1983 and from 1972 to 1979 represented Jefferson County in the Texas House of Representatives. He has extensive experience in handling complex legal and political issues before state courts and federal courts, as well as federal and State agencies.

**Professional Activities and Memberships**

Mr. Powers has been a member of the Board of Directors of the State Bar of Texas and has held various posts as well in the American Bar Association and in the Texas and American Bar Foundations. He is a former Chairman of the Board of the Austin Chamber of Commerce. Mr. Powers is a member of the Maritime Law Association of the United States, the Federation of Insurance and Corporate Counsel and the National Association of Railroad Trial Counsel.

**Professional Honors**

He was named as a "Texas Super Lawyer" in general litigation law in the November 2003 issue of *Texas Monthly*.

**Educational Background**

Mr. Powers received a B.A. in 1962 from Lamar University and a J.D. in 1965 from the University of Texas. He was admitted in 1965 to practice law in Texas.

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July 25, 2006

The Honorable Sherwood Boehlert  
Chairman, Science Committee  
2320 Rayburn Office Building  
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 5<sup>th</sup> for the hearing entitled "Innovation and Information Technology: The Government, University, and Industry Roles in Information Technology Research and Commercialization." In accordance with the Rules Governing Testimony, this letter serves as formal notice that I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Very truly yours,



Pike Powers

PP/vh

Cc: Congressman Lamar Smith, *U. S. House of Representatives*  
Congressman Michael McCaul, *U. S. House of Representatives*

Chairman SMITH. Thank you. We appreciate your testimony.  
Mr. POWERS. Thank you, Lamar.

Chairman SMITH. Dr. Goodall, that is high praise. We look forward to your testimony.

Dr. Sanchez.

**STATEMENT OF DR. JUAN M. SANCHEZ, VICE PRESIDENT FOR RESEARCH; TEMPLE FOUNDATION ENDOWED PROFESSOR IN MECHANICAL ENGINEERING, UNIVERSITY OF TEXAS AT AUSTIN**

Dr. SANCHEZ. Chairman Smith, Congressman McCaul, I want to thank you for the opportunity to comment on this important subject of Innovation and Information Technology.

I will just begin by stating the obvious. I think there is overwhelming evidence that in the 21st century information technology will influence the welfare and security, and the quality of life of every citizen. It will be the fundamental pillar of modern society, modern science and engineering and will be a factor in business and every technological enterprise. The evidence is compelling. Over the last 10 years or so we have seen few areas of science that have had such a profound impact on society and the world. None has effected these changes at a faster pace.

From my perspective as a member of a major research university I know firsthand that the federal investment in information technology was very key to the wave of innovation that we have experienced in the last 10 years. This federal investment is what sustains a vibrant community of scholars and researchers at universities across the Nation.

This is the same community that created, among other things, the first web browser at the University of Illinois, and the Google search algorithm at Stanford, both of which in Thomas Friedman analysis were key factors in “flattening” the world. I think the return on the investment, even to a casual observer, has been extraordinary.

At the University of Texas at Austin research and education on information technology, Computer Sciences, Computer Engineering and Computational Science and Engineering are of the highest priority. I would like to mention the Texas Advanced Computing Center and our Institute for Computational Science Engineering.

The Texas Advanced Computing Center has established strong partnerships with several industry leaders in IT. As a consequence of that we have been able to provide significant computational resources on campus. That benefits researchers on campuses across Texas and across the Nation. We have been very, very effective in leveraging federal funding the center receives.

In the process we have engaged the industry in support of the Nation’s research agenda. At the Institute for Computational Engineering and Science we have faculty, students, and researchers using this powerful cyberinfrastructure to develop the next generation of applications. One example of these applications includes predictive modeling of cardiovascular bypass surgery, no doubt breaking new ground in the emerging field of Simulation Based Medicine. Developments like these promise to completely change medical practice in the future.

We are now looking at the emergence of a new field that the community has named "Simulation Based Engineering and Science." We are now evolving towards the pervasive use of simulation and high performance computing to predict with a high degree of confidence the outcome of the most complex biological, geophysical, engineering, scientific, behavioral, and social processes, and I would say political processes.

I refer to these two examples because I want to briefly comment on models of federal investment. First, let me stress that the major planned investments by the National Science Foundation in cyberinfrastructure will provide the next generation of computational platforms needed to keep us competitive at the international level in the coming age of science and technology.

These investments are greatly needed for us to gain, or some would say regain, unquestionable leadership in information technology. This investment in cyberinfrastructure, however, must be matched by the equally aggressive support of the research that will create the applications running on those platforms. I would like to join many of my colleagues in recommending the creation of long-term programs in simulation based engineering that cut across all directorates of NSF and other federal agencies.

With the Committee's indulgence I would also like to recommend the significant increase in federal support for programs aimed at the development of the next generation of software and hardware technologies that achieve high performance from thousands of computational nodes, that are easy to program and tolerate failure when running applications by the thousands of processes for many days and weeks. DARPA's High Productivity Computing Program is a good example of the type of program that I am referring to. I know that program involves also the National Science Foundation.

In my opinion conventional planning has three levels, cyberinfrastructure, applications, and the next generation of software and technology. This will bring significant balance to the federal research portfolio. Federal support of the three areas is, in my opinion, well aligned with the President's American Competitiveness Initiative. The principles behind each call for the federal investment to be a long-term high-risk research that prioritizes the investment in terms of impact on the Nation's economic competitiveness and addresses the current models in federal support of engineering and physical sciences.

With that I will also express my thanks for all you do on behalf of the people of Texas and the University of Texas also. Thank you very much.

[The prepared statement of Dr. Sanchez follows:]

PREPARED STATEMENT OF JUAN M. SANCHEZ

Chairman Smith, Congresswoman Johnson, Congressman McCaul, I thank you for the opportunity to comment on the subject of Innovation and Information Technology, and more specifically on the Government, University and Industry roles in IT research and commercialization.

There is overwhelming evidence, and a strong consensus among leaders in science and technology worldwide, that the broad range of disciplines and technologies encompassing information technology will be of critical importance to the industrialized world during the 21st century. Progress and prosperity in America will be greatly affected by the components of information technology, which include com-

putational and computer engineering and science, high-performance computing, simulation, high-bandwidth networks, high-volume data storage and management, computational visualization, and their underlying scientific and technological disciplines. Information technology will affect virtually every aspect of modern life; it will influence the welfare, security, and quality of life of every American as well as other citizens of the planet, and it will change the way information is distributed, represented, and manipulated. It will be a crucial factor in industrial competitiveness, a fundamental pillar of modern science and engineering, and a transforming factor in business, education, science, communication, medicine and virtually every technological enterprise.

The evidence is compelling. Over the last 10 years or so, few areas of science and technology have had such a profound impact in society and the world as information technology, and none has effected these societal changes at a faster pace. And we are, no doubt, just at the beginning of one the most significant and deeply transforming revolutions in human history.

Chairman Smith has put forward a set of key questions to be addressed during this hearing. In what follows, I attempt to respond to these questions from the perspective of an educator, researcher and administrator at a public research university.

- **How does the federal investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?**

Federal investment in information technology played a critical role in launching the wave of innovation that we have experienced in the last 10 years in business, education, communications, and research and development across all disciplines. This federal investment is what sustains a vibrant community of scholars and researchers at universities across the Nation; a community that created, among other things, the first web browser at the University of Illinois, and the Google search algorithm at Stanford, both of which, in Thomas Friedman analysis, were key factors in “flattening” the world. The return on the investment, even to a casual observer, has been extraordinary.

Equally important is the impact of the federal investment in information technology research into virtually every field of science and engineering. In fact, this investment affects almost every aspect of the federal research portfolio and, directly or indirectly, promotes innovation across the entire science and engineering spectrum. A well-balanced information technology research portfolio is thus critical to national competitiveness in the 21st century.

- **What role does university research play in innovation in information technology? How do University balance federal and industry support for research projects? What are the barriers to the use of university results in commercialization of new information technology products?**

Historically, research universities in the U.S. have led the way in innovation in all areas of technology, and information technology is no exception. There are, however, unique aspects of information technology—such as its strong multidisciplinary nature, rapid pace of evolution and societal impact—that demand new approaches to research and education. In fact, many universities across the Nation have begun to restructure their academic programs in preparation for this information revolution.

At the University of Texas at Austin, research and education in information technology, Computer Sciences, Computer Engineering and Computational Science and Engineering are of the highest priority. Over the last several years, the University has made important investments in its physical infrastructure, upgraded its computational capacity, hired world-renowned faculty, and created and strengthen graduate programs and research centers. I should stress that this investment has been matched by major contributions from private individuals, industry, and the Federal Government. The federal investment has been in the form of major research grants awarded to the University by, primarily, the National Science Foundation, the Department of Defense, the Department of Energy, and NASA.

Our Texas Advanced Computing Center has established strong partnerships with several industry leaders in information technology, which have resulted in the deployment of major computational resources. This computing capability benefits researchers on campus, across Texas and the Nation. Last year, the Texas Advanced Computing Center joined NSF’s TeraGrid, which is the world’s largest, most comprehensive distributed cyberinfrastructure for open research. Researchers at the Center are also actively developing and deploying new software technologies that help connect and aggregate advanced computing systems, such as High-Performance

Computing, storage, visualization, networks, etc., into powerful computational Grids.

At the same time, at our Institute for Computational Engineering and Science, faculty, students and researchers are using this powerful cyberinfrastructure to develop the next generation of applications that will ensure the Nation remains at the cutting edge of innovation. One example of these applications include predictive modeling of cardiovascular bypass surgery, no doubt breaking new ground in the emerging field of Simulation Based Medicine. Developments like these promise to revolutionize future medical practice. There are many more examples of applications being developed at universities and at national and industrial laboratories across the Nation that will have profound, perhaps unimaginable impact on all areas of science and engineering.

In fact, we are witnessing the emergence of a new field that the community has named "Simulation Based Engineering and Science." The concept is not necessarily new, since it is practiced in many engineering disciplines, except that we are now evolving towards the pervasive use of simulation and high-performance computing to predict, with high degree of confidence, the outcome of the most complex biological, geophysical, engineering, scientific, behavioral, and social processes.

- **What areas of information technology research and what type of programs should the Federal Government support to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?**

Major planned investments by the National Science Foundation in cyberinfrastructure will no doubt provide the next generation of computational platforms critical to keeping the Nation competitive at the international level and at the cutting edge of information technology. And the consensus among the experts is that the investment has to be sustained and long-term in order for us to gain, and some will say regain, unquestionable leadership in information technology. It is clear, however, that the investment in cyberinfrastructure must be matched by an equally aggressive support of the research that will create the applications running in those platforms. So, I would like to join many of my colleagues in recommending the creation of a long-term, high-risk research program in Simulation Based Engineering that cut across all directorates of NSF and other federal agencies. Such program will not only develop the computational tools that will be indispensable in the 21st century, but they will help produce the next generation of multi-disciplinary scientists and engineers who will ensure the Nation remains at the cutting-edge of scientific discovery.

Such a crosscutting, multi-agency program in Simulation Based Engineering will help to bring balance to the federal investment in information technology. However, I would like to point out that a third aspect of the federal investment in information technology is in need of immediate attention, namely, the dearth of federal programs aimed at the development of the next generation of software and hardware technologies that achieve high performance on thousand of computational nodes, that are easy to program and that tolerate failure of individual components when running applications spanning thousands of processors for many days or weeks. The DARPA High Performance Computing Systems (HPCS) program, in partnership with several federal agencies, is to be commended for funding such research and development program. I would submit to the Committee that a significant increase in the level of funding of programs such as DARPA's HCPS is needed to properly balance the Nation's research portfolio since, by and large, the market currently does not reward companies for long-term, high-risk research in this area.

Federal investment in three critical areas of information technology—cyberinfrastructure, simulation based engineering and science, and next generation software and hardware technologies—are well aligned with the President's American Competitiveness Initiative and the principles behind the initiative. In particular: 1) the Federal Government will be fulfilling its responsibility to fund long-term, high risk research; 2) advances in information technology will continue to have a major impact, and on a relatively short time frame, on the Nation's economic competitiveness; and 3) the tools developed by information technology research will have a direct impact in the advancement of all disciplines, including engineering and the physical sciences.

#### BIOGRAPHY FOR JUAN M. SANCHEZ

Dr. Juan M. Sanchez is the Vice President for Research at the University of Texas at Austin and holder of the Temple Foundation Endowed Professorship #4 in the Department of Mechanical Engineering. He obtained his B.S. in Physics at the Uni-

versity of Cordoba, Argentina, 1971; M.S. in Materials Science, 1974; and Ph.D. in Materials Science, 1977 at the University of California, Los Angeles.

Dr. Sanchez is the author and co-author of over 140 technical publications on a wide range of topics in materials science and engineering. His current research interests are in the electronic, thermodynamic and structural properties of materials including inter-metallic compounds, magnetic and non-magnetic alloys, thin films and magnetic multi-layers. Primary interest is the development and application of first principles computational methods for the construction of phase diagrams of multi-component material systems. Other research interests include the development of laser-controlled selective chemical vapor deposition processes for metals, alloys and ceramics.

Dr. Sanchez serves on the Council of Federal Relations of the Association of American Universities; on the Board of Directors as Council Vice Chair for the Oak Ridge Associated Universities, and the Texas Nanotechnology Initiative. He also serves as a Representative to the Government-University-Industry Research Roundtable of the National Academies, as Trustee for the Southeastern Universities Research Association, Inc., as a Board Member of the Institutional Oversight Committee for the National Partnership for Advanced Computing Infrastructure (NPACI), the Board of Visitors of the U.S. Army War College, Member of the International Consulting Board, Advisory Board for the Texas Coalition for Capital, the National Scientific and Policy Advisory Council for the Hogg Foundation for Mental Health, and Member of the AusTech Alliance of the Greater Austin Chamber of Commerce.



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May 2, 2006

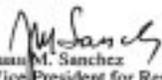
The Honorable Starwood Boehlert  
Chairman, Science Committee  
2120 Rayburn Office Building  
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 5, 2006 for the hearing entitled "Innovation and Information Technology: The Government, University, and Industry Roles in Information Technology Research and Commercialization." In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding I currently receive related to the hearing topic.

I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,

  
Juan M. Sanchez  
Vice President for Research

JMS:ar

Chairman SMITH. Thank you, Dr. Sanchez.  
Dr. Goodall.

**STATEMENT OF DR. RANDAL K. GOODALL, DIRECTOR OF  
EXTERNAL PROGRAMS, SEMATECH**

Dr. GOODALL. Thank you very much. I appreciate the emphasis here on brevity and you compelled me to actually edit out part of my remarks but they are in the record. As people here assembled know, that is not always easy. Chairman Smith and Congressman McCaul, I know you both, I know your service, and I appreciate and thank you very much for having us and inviting me here today.

As a representative of the industry, the semiconductor industry in particular, I am going to be responding to your question about the IT industry with respect to the hardware side. I mean specifically the semiconductor chip point of view which is really the heart of information systems ultimately.

It is worth reminding ourselves what the semiconductor segment achieves and the cost of that achievement, usually referred to as "Moore's Law." This year a quintillion transistors will be manufactured around the world. They will be put into 100 billion chips. They will all work. A quintillion. You don't use that word very often in industry. All the world's memory from 25 years ago is on one single wafer today. Semiconductors became the world's first large-scale nanotechnology industry several years ago when the 90 nanometer chip generation went into volume production. Every two or three years that dimension will be halved and halved again.

Semiconductor companies spend 15 to 20 percent of revenue on R&D to make this all happen. A single plant developing 300mm wafers, as we now have two of them in Texas, cost \$3 to \$4 billion for one. Unfortunately most are being built outside the United States. Ultimately, the semiconductor industry is an innovation power house and among the world's highest in value-add and economic multiplier.

Much of the world's information technology industry growth and concomitant wealth and opportunity creation depends upon the continued trust and belief that an impossible product designed today will come to market just in time for smaller, faster, denser chips to enable it. We never want to stop believing that is true because when it does, the entire industry basically grinds to a halt.

I am from SEMATECH which is an R&D consortium with members including most of the world's largest leading edge semiconductor manufacturers. The consortium was spawned in a previous era back in '87 when the question of the U.S. competitiveness in the IT marketplace was again one of concern. SEMATECH is a 50/50 partnership in the U.S. Government and U.S. industry and is instrumental in turning the tide for semiconductor manufacturing and the chip manufacturing equipment supply chain in America, and is a clear legacy of a government-industry partnership that actually worked.

The world today is a very different place, although we are asking the same questions, I suppose. After its early success, SEMATECH flexibly adapted to the global environment of our industry, and is today an international, structured family of R&D organizations that continues to propel the industry forward.

You laid out several questions which I will address each one and I will answer them in light of the last 20 years of semiconductor research, development, and commercialization collaboration that SEMATECH has lived through.

The first question is how does federal investment promote innovation. The federal investment in information technology research always has and always will play a crucial role because it literally enables the basic layers of the IT ecosystem the most fundamental research.

I have actually included a figure in the document that you can look at at your convenience. It outlines for our industry the collabo-

ration pipeline that begins with the most advanced research that is 15 to 20 years into the future in terms of use. The Microelectronics Advanced Research Corporation Research, which the government actually does support; the SRC research which is principally universities; SEMATECH which cuts a wide slash in the middle of development; then the various private collaborations and then actually post competitive collaborations that SEMATECH also supports in manufacturing initiatives.

This pipeline is a requirement for just the wild and crazy technology innovation world that this industry actually has to deal with to do its job in the economy. These three competitive efforts are really threaded together by what is called the International Technology Roadmap for Semiconductors which I highlight because it is important. It is now a web-based document of nearly 1,000 pages and is annually updated by nearly 1,000 people in our industry because it is very important.

It is worth noting in this figure that a lot of the research that is in our industry is not exclusively embodied in the United States. It is true that the U.S. does enjoy a legacy of semiconductor leadership and we, of course, have a vested interest in that because the Federal Government drives along defense and homeland security interests. But it is not an entitlement that the U.S. be a leader. As the era of nanoelectronics and advanced technology convergence emerges simultaneously around the world, we will find ourselves competing in a pre-globalized mega-industrial complex in technology and we have got to be ready for that.

Federal funding in the figure that I showed there is heaviest in the areas that are focused on the far future (right hand side) and they systematically decrease as efforts converge to the now which is where we are all competing in the industrial world.

The Semiconductor Industry Association, as you have probably heard from them, has established priorities for federal research funding. That includes substantial increases in funding for the physical sciences, funding for the Focus Center Research Program by DOD, and specific support of NIST in various of its activities. This funding provides feedstock for the collaboration pipeline. It is not sufficient to the task because we have research gaps still and they define those very well. Additional funding from any government will assure a higher level of participative innovation for that region. That is just another one of the facts of globalized R&D environments that governments that are putting money on it are going to be participating in the benefits for that.

Your second question had to do with the university research-industry relations. The speakers around me are going to speak to that in great detail but I will summarize my remarks there. It is challenging to build adequate research programs that fit into a fast-moving commerce industry. There are some challenges to tie into university research and commercializing it.

I have three outlines that I will summarize in one sentence each. The first one is that the industry moves at such amazing speed. I call it warp speed in here. It actually exceeds in many cases the speed of the university to move graduate students into programs and to hit the industry's timelines as defined in the roadmap so often research is left behind.

The industry is also huge in complexity and cost of R&D. A lot of times universities just don't have the infrastructure to do the work that has the right match to what the industry is doing. I will talk to that in my recommendations because that is an area that perhaps you can help with.

And then, finally, IP mapping is often difficult in our industry in particular simply because it is so complex to manufacture chips that only large portfolios of IP really sort of contain the problem space of the industry. Single research results that are usually, certainly once we think about it, it is going to provide the model of IP at universities. How they contribute to the technical content of the industry often doesn't match the economics.

Thirdly, you asked how can the Federal Government support this competitiveness going forward? I have three basic recommendations for that I would like to read for you.

The first one is Innovation Process Connection: As the semiconductor industry begins to mature in the coming 10–20 years, staying on Moore's Law will require a broader base of technology R&D investments than might be afforded by our industry alone. Other industries that need nanoscale fabrication, measurement techniques, and exotic materials (which is what we need) can help support that effort if two things occur:

- (1) There is intentionality in technology convergence so that common industrial needs are identifying and optimized; and there is sufficient and appropriate R&D infrastructure and funding direction to drive these efforts together, beginning with research. I believe the U.S. Government, to really keep the U.S. competitive in this kind of global technology converging future, should consider offering specific support and direction to emerging technology areas requiring nanofabrication and nanomanufacturing to construct roadmaps with clear linkages to the semiconductor industry so that we find these convergences and we actually work them on our own soil.
- (2) Secondly, that we are using the collaboration example of the semiconductor industry as a model and offer support to other IT, and emerging technology segments, for building collaboration pipelines of their own that incorporate the best capabilities that the U.S. has to offer.

Secondly, I would like to recommend Innovation Infrastructure Connection. The Federal Government can form partnerships with states to create higher funding impact by matching state economic development programs targeted at semiconductor manufacturing and technology development. This should be particularly supported when existing leading-edge semiconductor infrastructure (buildings, labs, equipment, know-how) can be expanded for multiple use by emerging technology researchers like biotech scientists and nanotech scientists. I believe interagency collaborations with the states in convergent technology infrastructure should be increased and rewarded.

Thirdly, and finally, Innovation People Connection. This has been mentioned by every speaker and I am going to say the same thing. The Federal Government can identify additional funding for

nanoelectronics and other convergent technology education and workforce development programs, in particular those that engage advanced sites for hands-on training purposes. Again, partnerships with the states will bring the largest impact. A significant challenge that I wish I had clearance for. I would love to work on a clearance report.

There is a significant challenge that requires the collaboration of educators and industry to get early experience and exposure to high school students in particular to technology career opportunities to motivate them to engage the curriculum that they are experiencing. They have some good curriculum. They just need to be motivated to engage it so they become the people of the 21st century. I think that is extremely important.

In closing I would like to say in the modern world there is no country, including ours, that can afford to lose any piece or portion of its technology research, technology development, and technology manufacturing base. These are increasingly interconnected due to complexity and high cost. Losing pieces of them always takes more than you think away from them.

SEMATECH is an independent industry representative organization. It has a long and rich history of driving technology development, transferring research results from universities, commercializing technology, roadmapping the collaboration pipeline, and assembling and operating sophisticated R&D infrastructure. We offer our support to you for further discussions on any of these matters. Thank you very much.

[The prepared statement of Dr. Goodall follows:]

PREPARED STATEMENT OF RANDAL K. GOODALL

Honorable Members of the Committee on Science of the House of Representatives of the United States, I would like to thank you for inviting me to speak on the important subject of how the government-industry-university research partnership maintains U.S. competitiveness in the global information technology (IT) market. As a representative of industry—the semiconductor industry segment of information technology—I will be responding from the perspective of the “hardware” side of the IT industry, specifically the semiconductor chips that are the heart of all information systems. Even more specifically, my comments are most directly derived from the issues of the technology intensive domains of logic processors and high-density memory chips.

**Background**

It is worth reminding ourselves what the semiconductor segment achieves and the cost of that achievement, usually referred to as “Moore’s Law”:

- This year, ~1 quintillion transistors and/or memory bits will be manufactured on ~100 billion chips. They will all work.
- A single 300mm wafer today contains as much memory as the entire world’s production of DRAM in 1985. One gigabit of DRAM cost \$32,000 in 1985, but is a mere \$8 today.
- Semiconductors became the world’s first large-scale nanotechnology industry several years ago when the 90 nanometer chip generation went into volume production. Today, transistors with active areas less than 50 nanometers across with insulating materials applied to them in layers only a few nanometers thick are being produced. In less than a decade, these dimensions will be halved again.
- 15–20 percent of semiconductor revenues are spent on R&D. A single 300mm wafer fabrication plant costs ~\$3–\$4 billion. Most are being built outside the U.S.
- Ultimately, the semiconductor industry is an innovation power house and among the world’s highest in value-add and economic multiplier.

Much of the world's information technology industry growth and concomitant wealth and opportunity creation depends upon the continued trust and belief that an impossible product, designed today, will come to market just in time for smaller, faster, denser chips to enable it.

SEMATECH is an R&D consortium with members including most of the world's largest leading edge semiconductor manufacturers. The consortium was spawned in a previous era (1987) when the question of U.S. competitiveness in the IT marketplace was one of active concern. Initiated as a 50–50 partnership of U.S. Government and U.S. industry, SEMATECH was instrumental in turning the tide for semiconductor manufacturing and the chip manufacturing equipment supply chain in America—a clear legacy of a government-industry partnership that worked. The world of today is a very different place (although the questions we find ourselves asking seem familiar). After its early success, SEMATECH flexibly adapted to the global environment of our industry, and is today an international, structured family of R&D organizations, which continues to propel the industry forward.

#### Committee Questions

The Committee has laid out three key questions to be addressed in this hearing, and I will answer them in light of the last 20 years of semiconductor industry research, development, and commercialization collaboration as embodied in SEMATECH.

##### **1. How does the federal investment in information technology research promote innovation in information technology and foster the development and commercialization of new applications?**

The innovation ecosystem in any area, including IT, has many layers. The most fundamental is the basic science and engineering research that expands the boundaries of knowledge and brings new ideas, useful or not, into the environment. At higher levels in the ecosystem, we find product development, commercialization, manufacturing, and industrial scaling. Federal investment in information technology research has and will play a crucial role in quite literally enabling the basic research layer of the IT ecosystem. Industries broadly have to a large degree come to rely on universities for this research, and to an increasing degree, anticipate its funding through federal grants and sponsored research. Beginning in the 1980's and enabled by the *National Cooperative Research and Production Act*, the semiconductor industry began the task of constructing a cooperative framework for solving the increasingly daunting problem of bringing together all the technologies needed for the industry. It was realized that much of that effort is “pre-competitive,” that is, needed by all participants but not strongly connected to their own core business value propositions.

Figure 1 illustrates the collaboration pipeline of the semiconductor industry today. Although the specific companies at each stage vary somewhat, there is consistent participation by advanced logic and memory manufacturers all through this pipeline. The pre-competitive R&D efforts in the semiconductor industry globally are coordinated through the *International Technology Roadmap for Semiconductors* (ITRS), a (now web-based) document of nearly 1,000 pages, annually updated by nearly 1,000 contributors around the world. Note that this pipeline is not exclusively embodied in the U.S. While it is true today that the U.S. enjoys a legacy position of semiconductor leadership (as well as a continued vested interest in that leadership driven at the federal level for defense and homeland security reasons), it is by no means an entitlement, and as the era of nanoelectronics and advanced technology convergence emerges *simultaneously* around the world, we will find ourselves competing in a pre-globalized mega-industrial complex.

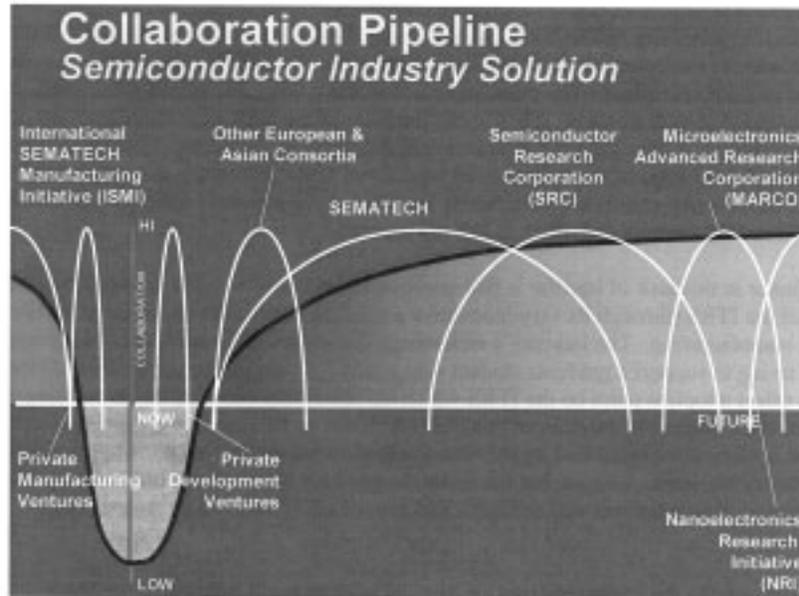


Figure 1. Collaboration pipeline of the semiconductor industry.

In Figure 1, federal funding is heaviest in areas that are focused on the far future (right hand side) and decreasing applied as efforts converge on the competitive “now” (the vertical axis on the left). The Semiconductor Industry Association (SIA) as the representative organization of the industry in America, has established priorities for federal technology research funding ([http://www.sia-online.org/backgrounders\\_technology\\_funding.cfm](http://www.sia-online.org/backgrounders_technology_funding.cfm)). I will not detail them here, but they include substantial increases in funding for the physical sciences through the NSF (through partnerships with SRC and in conjunction with the National Nanotechnology Initiative), the funding of the Focus Center Research Program (MARCO) by DOD, and specific support of NIST. This funding provides feedstock for the collaboration pipeline, although it is not sufficient to the task and additional funding from any government will assure a higher level of participative innovation for that region.

**2. What role does university research play in innovation in information technology? How do universities balance federal and industry support for research projects? What are the barriers to the use of university results in commercialization of new information technology products?**

As noted above, university research brings new ideas into the innovation ecosystem. Within the complex academic environment, there are several priorities that offer friction to the movement of these ideas to the marketplace. The most important is that a large fraction of these ideas are not honestly intended to ever go there. They are byproducts of the most significant mission of research universities—educating the scientists and engineers of the future. Commercialization (and commercializability) of these ideas is ad hoc. Even when research is directed by the funding source and the research results are specifically intended to contribute to a higher and specific mission, successful commercialization is still not assured.

One key factor in this lack of transfer is that semiconductor research often departs from the mainline of the ITRS (through its very innovative nature) and therefore sees a large barrier to entry into manufacturing. The industry’s technology conveyor belt is moving at “warp speed.” A professor trying to support a graduate student who needs 3–4 years to complete his Ph.D. thesis will often select a topical point on the ITRS which his laboratory can support (processing and test equipment, etc.). Since the duration of this Ph.D. effort can be two technology generations for the industry, it is often discovered that by the time the student has completed his

work, valuable data for the industry has been obtained, but the insertion point for that research has passed—the industry picked from whatever was available and moved on. These decisions are often irreversible.

Another challenge to the commercialization of university research is found in the sheer complexity and difficulty of beyond-leading-edge chip design and fabrication. A leading-edge company might employ hundreds of engineers and spend hundreds of millions of dollars developing a new chip technology. This is far beyond the capability of a university researcher, so he must focus on an increasingly small portion of the technical space and at an increasingly distant portion of the ITRS timeline. But he will almost always have significantly less capable infrastructure (usually older, donated equipment). Even in the best of circumstances, targeting these pinpoint selections so that they produce, within the vagaries of research, commercially blendable results is very challenging.

A final confounding factor for technology transfer in the semiconductor industry is IP. In the semiconductor industry, large portfolios of IP are often exchanged among industry players to acquire and/or maintain leading-edge design and production and capabilities. Isolated or disconnected patents on university developments can delay, complicate, or even kill the opportunity to integrate a university result into a semiconductor manufacturing process, tool, or material effort. Unless a portfolio is constructed and actively maintained, which is a sophisticated endeavor not often possible within the administrative structure of a university research commercialization office, semiconductor research results are difficult to process through the conventional thinking of the Bayh-Dole act, despite their potential for contributing to the industry's moving forward.

### **3. What areas of information technology research and what type of programs should the Federal Government support to maintain U.S. competitiveness? How do these areas complement the focus and investments of industry research programs?**

In addition to the specific directions provided by the SIA on research funding, R&D and manufacturing investment tax policy, and education and workforce development, I would like to offer the following for the Committee's consideration:

- **Innovation Process Connection:** As the semiconductor industry begins to mature in the coming 10–20 years, staying on Moore's Law will require a broader base of technology R&D investments than might be afforded by our industry alone. Other industries that need nanoscale fabrication, measurement techniques, and exotic materials can help support that effort if two things occur: (1) there is intentionality in technology convergence so that common industrial needs are identifying and optimized; and (2) there is sufficient and appropriate R&D infrastructure and funding direction to drive these efforts together, beginning at the research phase. Therefore, the U.S. government could consider:
  - Offering specific support and direction to emerging technology areas requiring nanofabrication and nanomanufacturing to construct roadmaps with clear linkages to the ITRS.
  - Using the collaboration example of the semiconductor industry as a model and offer support to other IT (and emerging technology!) segments in building a collaboration pipeline that incorporates the best U.S. capabilities.
- **Innovation Infrastructure Connection:** The Federal Government can form partnerships with states to create higher funding impact by matching state economic development programs targeted at semiconductor manufacturing and technology development. This should be particularly supported when existing leading-edge semiconductor infrastructure (buildings, labs, equipment, know-how) can be expanded for multiple use by emerging technology researchers. Inter-agency collaborations with the states in convergent technology infrastructure should be increased and rewarded.
- **Innovation People Connection:** The Federal Government can identify additional funding for nanoelectronics and other convergent technology education and workforce development programs that engage advanced sites for hands-on training purposes. Again, partnerships with the states will bring the largest impact. A significant challenge requiring collaboration of educators and industry is early experiential exposure of high school students to technology career opportunities to motivate them to engage the curriculum of the 21st century.

In the modern world, no country can afford to lose any of its technology research, development, and manufacturing base, even as these are increasingly interconnected due to complexity and high cost. I have fully avoided specific technical program recommendations today, as they are well documented elsewhere, and these additional details can be provided as needed. As an independent industry representative organization, with a long, rich history of driving technology development, transferring research results from universities, commercializing technology, roadmapping the collaboration pipeline, and assembling and operating sophisticated R&D infrastructure, we offer to you to please contact us for further discussions on any of these matters.

#### BIOGRAPHY FOR RANDAL K. GOODALL

Dr. Goodall received his Bachelor's of Science in physics from Caltech (1977) and his Master's (1979) and Ph.D. (1984) in experimental solid-state physics from the University of Oregon.

After working with an advanced software applications startup, Dr. Goodall entered the chip industry in 1987, joining ADE in Boston, Massachusetts to form the Systems Technology Group to identify and develop next generation measurement technologies, system architectures, and computational applications.

In early 1994, Randy joined SEMATECH as a Senior Member of Technical Staff in the Silicon Materials group on some of the world's earliest 300mm wafer efforts.

In late 1995, Dr. Goodall was one of six members of the startup team for the International 300mm Initiative (I3001), leading Enabling Technologies, including the silicon wafer, metrology, standards, and productivity programs. In 1998, the I3001 programs merged with International SEMATECH, and in 2000, Randy was named Associate Director of a new Manufacturing Methods and Productivity division, focusing on productivity for existing and future fabs and equipment.

Beginning in 2002 on special assignment to the Office of the Chief Executive, Randy worked on the \$200M leveraged funding for the Albany EUV program. He subsequently developed the Texas Technology Initiative (TTI) and worked with the Governor and other State and local officials to pass 2003 legislation which enabled funding for SEMATECH and university programs through a new Advanced Materials Research Center, spanning semiconductor, nanotechnology, biotechnology, MEMS, and advanced energy. As the first Director of the newly-formed SEMATECH External Programs office, Randy provided leadership in 2005 for the TTI, the State Strategy on Advanced Technology, and the \$200M Texas Emerging Technology Fund legislation.

Dr. Goodall has published numerous papers on silicon wafer technology, R&D collaboration, industry technology transitions, including 300mm wafers, and productivity modeling. He continues to engage local, State, and national government efforts to drive technology innovation and economic development, and he works with technology leaders, university administrators and researchers, and State officials to develop mechanisms for co-leveraging the semiconductor infrastructure of SEMATECH and the nanofabrication needs of emerging technologies.



May 2, 2006

The Honorable Sherwood Boehlert  
Chairman, Science Committee  
2320 Rayburn Office Building  
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 12<sup>th</sup> for the hearing entitled "*The Future of Computer Science Research in the U.S.*". In accordance with the Rules Governing Testimony, this letter serves as formal notice of the federal funding SEMATECH and its subsidiaries currently receive related to the hearing topic.

- **Grant** from DARPA to University of Texas at Austin # HR0011-06-1-0005; subgrant # UTA05-789 to Advanced Technology Development Facility, Inc., (ATDF) a subsidiary of SEMATECH  
**Amount of funds to ATDF:** \$1,994,308  
**Federal Agency:** Department of Defense, DARPA  
**Fiscal Year Received:** 2006
- **Grant** from Department of Labor to Texas Workforce Commission; subgrant to Austin Community College (# 1406WSW2); subcontract to ATDF (# 1406WSW002),  
**Federal Agency:** Department of Labor, Workforce Investment Act, Section 134 [29 U.S.C.A> Section 2864]  
**Amount of funds to ATDF:** \$1,963,000  
**Fiscal Year Received:** 2006

Sincerely,

Randy Goodall  
Director of External Programs  
SEMATECH

Chairman SMITH. Thank you, Dr. Goodall.  
Dr. Iscoe.

**STATEMENT OF DR. NEIL ISCOE, DIRECTOR, OFFICE OF TECHNOLOGY COMMERCIALIZATION, UNIVERSITY OF TEXAS AT AUSTIN**

Dr. ISCOE. Chairman Smith, Congressman McCaul, for the sake of brevity I am going to summarize what I have in written form.

We live in an age in which inventions that were previously the stuff of science fiction are pretty common. Cell phones, computers, and other information technologies shape our reality and give us new ways to see what the future will bring.

Predicting the future is a risky bet, a difficult bet for companies with payroll to make and stockholders to satisfy. Even sophisticated market research cannot determine the needs of markets that do not yet exist. How is it possible then to choose where to spend development dollars when it is ultimately the market that determines success? How can the Federal Government work with universities and industry to maintain the United States' lead in innovation?

It is appropriate that these questions be asked at the 2006 WCIT because it is the ecosystem that is shared by the Federal Government, universities, and industry that created the science, protocols, the technology that is today's Internet.

Ecosystems include the participants, the complex set of relationships between them, and the externalities. The relationships between government agencies, universities, industry, and capital are linked that promote and sustain technological advancement even when buffeted by the cyclical flows of the market. Like a biological ecosystem, it is the robustness and complexity of the relationships, the links between the players, that makes the ecosystem work. If we can clarify and transparently understand, strengthen, and explain these relationships, we can accelerate our ability to maintain the United States' lead in innovation.

Since this is a Texas field briefing, let us look at a local example of an ecosystem. We can see the success of Bluebonnets in the display of color that we are privileged to watch each spring. Each season's output is determined by parameters that include the number of seeds from the previous spring, and the conditions (temperature, drought, bulldozers, animals) of the previous fall. Different seeds sprout under different circumstances so that there will always be a next season.

Similarly, the ecosystem of government, university, and industry can be both robust and sustainable. While not all scientific paths produce a commercial product, the interplay of federal funding, university exploration, and industrial application has the potential to provide enough inventions (i.e., the seeds) that U.S. entrepreneurs and corporations can turn them into products even while facing the challenges of cyclical economies, changing technologies, and international competition.

As industries mature, they become efficient at product improvement. However, as Clayton Christensen noted in "The Innovator's Dilemma," mature industries have difficulty understanding and valuing disruptive technologies. Furthermore, the uncertainties of

any particular research initiative and the continually changing competitive landscape have made it really difficult for U.S. corporations to operate on a long-time horizon. As the corporations close their industrial labs, the role of research in the United States is shifting to the universities.

Dr. Goodall just told us about the semiconductor roadmap by which Moore's Law continues. Roadmaps are excellent but the problem with roadmaps is that they do not allow for the changes in direction, disruptive technologies. As an example, Moore's Law is based on a process called lithography. Lithography is based on light. All the improvements in lithography, therefore, focus on improvements to this process.

What if instead of using light it was possible to build a mechanical device that could operate beyond the precision that we are currently operating at, at nanometer precision? At the University of Texas, with federal funding and industry collaboration, mechanical and chemical engineers came up with just that idea. They developed a new form of lithography based on mechanical processes, a nano-printing press, that eliminates the need to use light. UT has licensed the invention to a local startup, Molecular Imprints.

The company has received over \$60 million in investment capital, employs hundreds of people, and along with other industrial partners has received almost \$45 million in Federal Government funding through ATP, DARPA, and other initiatives. They are now producing a machine that will revolutionize the fabrication of semiconductors. That is just the beginning.

Just as Gutenberg's printing press changed the world by making books available to everyone, the nano-printing press will be able to mass produce nano devices. These devices will, in turn, spawn industries which are the stuff of today's science fiction.

Federal funding builds a base from which innovations such as the Internet and the nano-printing press can emerge. But just as all Bluebonnet seeds do not immediately result in Bluebonnets, not all ideas germinate in all conditions. Markets are the ultimate definition of success, and market conditions vary.

As a university commercialization office, we are match makers. We match university researchers with entrepreneurs and companies. We can take research prototypes and turn them into commercial products. Our goal is to systematically make the matching process between research ideas and commercialization partners more efficient, and to maximize the interactions so that new and existing relationships are more likely to result in serendipitous matches.

Existing programs such as SBIR, STTR, and ATP all help move technologies from the University to industry. State and regional programs such as the Texas Emerging Technology fund also provide funding for ideas that are not yet ready for standard commercial capital.

Backing up, in today's tech world it is easy to forget that the first computer was invented almost two centuries ago by Charles Babbage. His invention worked but the manufacturing precision of the 19th century was not sufficient to be able to build it. The 21st century is different. We can now build the things we can imagine.

The IT revolution has flattened the economic playing field creating challenges and opportunities for the United States. We no longer have a monopoly on technology production, communication, or even programming. But we are the acknowledged leaders of innovation. We have the talent and the ability to continue to grow a sustainable government/university/industry ecosystem that increases the yield, the societal and industrial yield, from scientific research.

What we do in the next decade is crucial. We must continue to pursue scientific research in university laboratories supported by government funding. The universities must work closely with entrepreneurs, investors, and established industry to move scientific discoveries into products that can be used by society.

The U.S. leads the world in innovation. By focusing on the relationships between government, universities, and industry, we can stay that way. Thank you.

[The prepared statement of Dr. Iscoe follows:]

PREPARED STATEMENT OF NEIL ISCOE

Chairman Smith, Congressman McCaul, thank you for this opportunity to testify today to the Committee on Science. I work with Dr. Sanchez and direct the University of Texas at Austin's commercialization of technology.

We live in a technological age in which inventions, that were previously the province of science fiction, are now commonplace. Cell phones, computers, and other information technologies shape our reality, and give us new ways to see what the future will bring. In retrospect, the multitude of new technologies and products are the logical consequence of known technology trends. But at the time a technology is introduced, its impact is rarely understood.

Predicting the future, however, is a difficult and risky bet for companies with payroll to make and stockholders to satisfy. Even sophisticated market research cannot determine the needs of markets that do not yet exist. In 1943, Tom Watson, the CEO of IBM predicted that "there is a world market for maybe five computers." In 1952, IBM revised its forecast to predict that the world market for computers would be ten times the original estimate. Corporations make market predictions based on the markets that they can see.

How is it possible, then, to choose where to spend development dollars, when it is ultimately the market that determines success? How can the Federal Government work with Universities and Industry to maintain the United States lead in IT technology?

It is appropriate that these questions be asked at the 2006 World Congress on Information Technology; for it is the Federal Government's investments in IT research that created the science, protocols, and alphabet soup of acronyms that are the Internet. In the interest of time, I will not give the history of the Internet, but note that as a case study, the development of the Internet illustrates the successful operation and future potential of the ecosystem shared by the Federal Government, U.S. Universities, and U.S. Industry.

Ecosystems include their participants, the complex set of relationships between them, and the externalities that affect them. The relationships between Government agencies, Universities, Industry, and capital, are links that promote and sustain technological advancement even when buffeted by the cyclical flows of the market. Like a biological ecosystem, it is the robustness and complexity of the relationships—the links between the players—that makes the ecosystem work. If we can clearly and transparently understand, strengthen, and explain these relationships, we can accelerate our ability to maintain the United States' lead in innovation.

Since this is a Texas field briefing, let's look at a local example of an ecosystem. We can see the success of Bluebonnets in the display of color that we are privileged to watch each Spring. Each season's output is determined by parameters that include the number of seeds from the previous Spring, and the conditions (e.g., temperature, drought, bulldozers, animals) of the previous Fall. Different seeds sprout under different circumstances so that there will always be a next season.

Similarly, the ecosystem of Government, University, and Industry can be both robust and sustainable. While not all scientific paths produce a commercial product, the interplay of federal funding, university exploration, and industrial application

has the potential to provide enough inventions (i.e., the seeds) that U.S. entrepreneurs and corporations can turn them into products even while facing the challenges of cyclical economies, changing technologies, and international competition.

As industries mature, they become efficient at product improvement. However, as Clayton Christensen observed in *"The Innovator's Dilemma,"* mature industries have difficulty valuing disruptive technologies. Furthermore, the uncertainties of any particular research initiative and the continually changing technological and competitive landscape have made it increasingly more difficult for U.S. corporations to operate on a long time horizon. As the corporations close their industrial labs, the role of research in the United States is shifting to the Universities.

This is where the Federal Government, Universities, startups, and early stage investment capital can keep the ecosystem healthy. As an example, let's look at the fundamental process, lithography, behind Moore's law and the twenty year semiconductor roadmap by which Moore's law continues. The problem is that roadmaps do not allow for the changes in direction (i.e., disruptive technologies).

Lithography is a photographic process based on light. Improvements in lithography therefore focus on light. But what if, instead of using light, it was possible to build a mechanical device that could operate within the nanometers of precision previously achieved with light? At the University of Texas, with Federal Government funding and Industry collaboration, mechanical and chemical engineers came up with that idea. Systematically attacking obstacles, they developed a new form of lithography, based on mechanical processes—a nano-printing press—that has the potential to disruptively eliminate the need to use light, thereby extending Moore's law. The University of Texas has licensed the invention to a local startup, Molecular Imprints.

The company, which was founded in 2001, has received over \$60 million in investment capital, and along with other Industrial partners, almost \$45 million in Federal Government funding through ATP, DARPA, and other initiatives. The company is now producing a machine that has the potential to revolutionize the fabrication of semiconductors. But that is only the beginning. Just as Gutenberg's printing press changed the world by making books available to everyone, the nano-printing press has the potential of mass producing nano-devices. These devices will, in turn, spawn industries which cannot yet be seen.

Federal scientific funding builds a base from which innovations such as the Internet and the nano-printing press can emerge. But just as all Bluebonnet seeds do not immediately result in Bluebonnets, not all ideas germinate in all conditions. Markets are the ultimate definition of success, and market conditions vary.

As a University commercialization office, our goal is to work with government and industry to systematically make the matching process between ideas and commercialization partners more efficient, and to maximize the interactions so that new and existing relationships are more likely to result in serendipitous matches. Existing programs such as SBIR, STTR, and ATP all help move technologies from the University to Industry. State and Regional programs such as the Texas Emerging Technology Fund fund ideas that are not yet ready for commercial capital.

In today's high tech world, it is easy to forget that the first computer was invented almost two centuries ago by Charles Babbage. His invention worked, but the manufacturing precision of the 19th century was not, at the time, sufficiently advanced to build his machine. In the 21st century, we are living in an age in which innovations are being delivered at an exponentially increasing rate.

The IT revolution has flattened the economic playing field, creating both challenges and opportunities for the United States. We no longer have a monopoly on technology production, communication, or even programming. But we are the acknowledged leaders of innovation. We have the talent and the ability to continue to grow a sustainable Government/University/Industry ecosystem that increases the yield from scientific research.

The next decade is crucial. We must continue to produce scientific results in University laboratories supported by government funding. The Universities must work closely with entrepreneurs, investors, and established industry to move scientific discoveries into products that can be used by society.

The United States leads the world in innovation. By focusing on the relationships between Government, Universities, and Industry, we can stay that way.

#### BIOGRAPHY FOR NEIL ISCOE

Neil Iscoe is Director of the Office of Technology Commercialization for The University of Texas at Austin. Dr. Iscoe is an experienced entrepreneur, having founded his first technology company, Statcom, in 1979. Formerly he was founder and CEO

of eCertain, a company that sold secure transaction solutions for legal and financial markets.

Prior to founding eCertain, he was the Division Manager of Advanced Technology for EDS. In this capacity, he established and managed an R&D laboratory, developed and deployed software technologies that reduced costs for the EDS business units, evaluated technology acquisitions, and built a Financial Trading and Technology Center at the University of Texas at Austin. Dr. Iscoe has also worked as a researcher at the Microcomputer and Electronics Consortium (MCC), where he focused on methods of improving software development practices and conducted field studies of large software projects that included telephony, defense, and enterprise applications.

Dr. Iscoe has an engineering degree from the University of Wisconsin and an M.S. and Ph.D. in Computer Sciences from the University of Texas at Austin. He remains an Adjunct Professor at UT in the Computer Sciences Department. Appointed by Texas Governor Rick Perry, Dr. Iscoe serves on the Texas Product Development and Small Business Incubator Advisory Board and was a founding member of the Central Texas Regional Center of Innovation and Commercialization Executive Advisory Board. He has also served on the Texas State Strategy on Advanced Technology team and on the Texas Information and Computer Technology Industry Cluster team. Dr. Iscoe was a founding member of the Austin Technology Council and is a frequently requested speaker at international conferences and programs.



OFFICE OF TECHNOLOGY COMMERCIALIZATION  
THE UNIVERSITY OF TEXAS AT AUSTIN

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05 May 2006

The Honorable Sherwood Boehlert  
Chairman, Science Committee  
2320 Rayburn Office Building  
Washington, DC 20515

Dear Congressman Boehlert:

Thank you for the invitation to testify before the Committee on Science of the U.S. House of Representatives on May 5<sup>th</sup> for the hearing entitled "*Innovation and Information Technology: The Government, University, and Industry Roles in Information Technology Research and Commercialization.*" In accordance with the Rules Governing Testimony, this letter serves as formal notice that I received no federal funding directly supporting the subject matter on which I testified, in the current fiscal year or either of the two preceding fiscal years.

Sincerely,

A handwritten signature in black ink, appearing to read "Neil Iscoe".

Neil Iscoe, Ph.D.  
Director

## DISCUSSION

Chairman SMITH. Thank you, Dr. Iscoe.

Before we go to questions I just wanted to make a couple of brief comments. One is to emphasize just how important federal funding of research and development and information technology is. You all probably are aware of this but it never ceases to impress me that when we talk about getting support from R&D examples include the Internet, databases, data mining, speed recognition. Other examples would be Red Ralier's assertion and so forth, all examples of federal R&D.

Also I am going to make a couple of quick comments about some of your testimony that I thought was particularly relevant and insightful and useful as well. Dr. Freeman, you mentioned, which I did not realize, that National Science Foundation research money went to two co-founders of Google back when they were students at Stanford University. I have a special interest in Google and didn't realize the National Science Foundation played a part.

Pike, on your testimony, you actually emphasized as well in your answer to the fourth question where you came up with a suggestion that I also had not heard before. You said in regard to the question what are the barriers to use of university results in commercialization of new information technology products. To me the biggest barrier is the U.S. does not have sufficient investment funds to take the university research results that are typically theoretical or conceptual stage to a proof of concept in prototype product stage.

My opinion from existing companies is it is easy to obtain the prototype stage. However, I think we are short on support of the middle stage where the theoretical conceptual ideas are turned into prototypes. This is often called the Valley of Death. That, to me, is a fine source of some additional funding from the government just as you suggested.

Dr. Sanchez, you mentioned the creation of a long-term high-risk research program and simulation-based engineering that cuts across all directorates of the National Science Foundation and other federal agencies. Another example of a novel idea. Again, you give an example of where we can direct some of our funds.

Dr. Goodall, you mentioned four of these examples but I am going to mention one example that you did not mention in your oral testimony but you mentioned in your written testimony, that is that a single 300mm wafer today contains as much memory as the entire world's production of DRAM from 1985. One gigabit of DRAM cost \$32,000 in 1985 but is a mere \$8 today. If that doesn't show how far we have come, I don't know what does. That actually makes Moore's Law look pretty small.

Dr. Iscoe, how could we forget your Bluebonnet metaphor ecosystem. I think you are exactly right. The Bluebonnet ecosystem applies equally as well to what I described at the university and government level and how they all fit together so appreciate your comments there.

Dr. Freeman, let me address my first question to you. What is the single most important thing that the government has done to help the information technology succeed?

Dr. FREEMAN. That is, of course, a hard question to answer but I believe that my friend and colleagues at the other end of the table, Neil Iscoe, has the answer and that is the investments of the Federal Government have created exactly that ecosystem that he was talking about. It started, as I mentioned, with research investments in the 1950s, largely militarily oriented in those days. That started to create a cohort of engineers, of scientists. It helped build up our universities. If you look at what federal funding has done since, over all I would have to say it is creating that ecosystem. If I might, I would just remark that I believe the *Gathering Storm* report that Mr. Powers mentioned and, indeed, we all believe it is an extremely important report, addresses exactly that issue. It is one that we considered at the National Science Foundation to be extremely important, as you know. We focused on the innovation research and education. Indeed, my directorate funded last year a study by the National Academy precisely on the subject of the ecosystem of IT innovations.

Chairman SMITH. Thank you, Dr. Freeman. You will understand why I'm letting everyone else answer this question except for you. Dr. Powers, I will start with you. The question is this. The National Science Foundation budget increased by eight percent, which is a pretty healthy increase. If you all will respond, if you could, and determine how you would use that extra eight percent. Where would you want that to go in the National Science Foundation this year?

Dr. Powers.

Mr. POWERS. By the way, I will reiterate my personal, and I believe most of the people I know who agree with what they do every day, support the competitiveness initiative and these issues because I think they are terribly critical. Mr. Chairman, I think my bend, and you have probably heard it from the university perspective, of the seed that we developed in the Big 12 center would be to support and encourage the nurturing of collaborative efforts for universities and business and the private sector all have to come together in new and meaningful innovative ways to make a dramatic change. I mean, I think Dr. Goodall spoke to it in a SEMATECH context. It has been a very key ingredient in our Texas technology initiative to encourage disrupting technology, to encourage new things. We think we have got to bring the best minds and the best thinkers together. The bottom line and my answer would be collaborative, cooperative, multi-disciplinary, multi-institution type approaches. When we put that much mass and that much horsepower we achieve a result that is dramatically different than what would otherwise be obtained.

Chairman SMITH. Thank you.

Dr. Sanchez.

Dr. SANCHEZ. Well, I totally agree that investments should go into multiple programs that are sufficient in scope for the 21st century. The National Science Foundation has had a very successful program of science and technology centers, materials research centers that bring together different components of each university and industry to tackle challenges. The community at large is full of ideas. They know what are the problems that we need to solve long-range, long-term. I am sure the National Science Foundation

once they put the program of this type into place, it is not short of good proposals and good ideas. Most of the events should go into collaborative work and specifically focusing on challenges.

Chairman SMITH. Thank you, Dr. Sanchez.

Dr. Goodall.

Dr. GOODALL. I have to answer the question by elaborating about my second answer and that is I would probably recommend something to collaboration but specifically in convergent technologies, biotechnology and nano, the things that have verification and are potentially huge revolutionary.

In fact, in the future the money doesn't have to go to industry but industry is where a lot of these nano fabrication infrastructure, research labs like our lab at SEMATECH, which is part of a partnership in Texas, sort of made that available for use by outside companies and they come to us. Since we have a specific mission and focus on semiconductors, what we have are hundreds and millions of dollars.

There are no equivalents of that anywhere in the U.S. at the university. But we have that capability there. It is very directed to what we are doing. I would take some of that funding and not give it to industry but give it to the university research community in order to partner with industry to bring the additional small capability needed to turn that in a verification focus on semiconductor, into a focus that can support advanced energy and support nanotechnology.

We are talking with these university researchers right now about doing that. The fact is that the funding is incremental but it would still be beyond their means so that is what I would do with the money.

Chairman SMITH. Thank you.

Dr. Iscoe.

Dr. ISCOE. Agreeing with the previous comments, multi-disciplinary, big ideas. Disruptive technologies by their nature are technologies that basically create new industries and cause old industries to be replaced. Universities are unique in this country in that universities can handle long research and can with the help of the Federal Government be able to perform research. It doesn't have meaty commercial application short-term but has a phenomenal industry application longer-term.

Chairman SMITH. Thank you. Let me ask one more question. Dr. Iscoe, I will start with you. What do you think is the single most important current government program that helps the information technology industry?

Dr. ISCOE. There are many programs that help the industry. Dr. Freeman had mentioned SBIR and ATP. There are a variety of—let me back up for a second. It is not so much about individual programs. It is the sets of all programs that make up this overall ecosystem. If you look at the development of the Internet, it started with three universities connected to computers. There were a variety of nets that got together, protocols, TCP/IP, and all sort of acronyms we developed.

Those all came about through various programs. Together they all resulted in this thing. The Internet existed before the World

Wide Web existed. It is just that most of the public didn't know it. It is difficult to pin one particular thing down.

Chairman SMITH. Dr. Goodall.

Dr. GOODALL. I guess I will cheat. One of them is DARPA. Although DARPA, in the Department of Defense, is not quite a program, it is an agency, but I think many of the things you listed actually came through them in things like global positioning system and all these things. I think the federal need for advanced technology through the military needs and university and industrial environment so I would say DARPA is the place where that sort of thing happens.

The other one I would probably note is the National Nanotechnology Initiative which actually falls under several agencies in terms of how it is authorized because it drives the very far out long-term convergent technology research. NIH and DARPA are the two places that I think are very valuable.

Chairman SMITH. Okay.

Dr. Sanchez.

Dr. SANCHEZ. It is always difficult to single out just one program. It is clear the—

Chairman SMITH. You can always say the National Science Foundation.

Dr. SANCHEZ. National Science Foundation has several supports for the IT community. I agree with Dr. Goodall that the nanotechnology initiative is a good model for finding other components of IT because it crosses different agencies, all directorates of NSF. One of the big problems that NSF is funding right now is an outbreak of cyberinfrastructure of this country relative to international so that is very important. It is not sufficient but I think that if this commitment to increase the funding in the physical sciences came to pass, I would hope that more programs such as nanotechnology within the technology initiative will be undertaken.

Chairman SMITH. And nanotechnology kind of fits that definition of where products maybe are not being realized as much as they might be right now. That would be more of a role for government. Although I don't think we will have to wait two years.

Dr. SANCHEZ. Nanotechnology is beginning to pay off. I think that similar initiatives in the information technology area will have potentially a bigger impact and will come to pass faster.

Chairman SMITH. Thank you, Dr. Sanchez.

Dr. Powers.

Mr. POWERS. Thank you, Mr. Chairman. In a rash of political correctness I agree with all of the previous speakers but a couple of salient points. One, if you want to produce an impact and make a result, you can cook \$4 billion up for the National Nanotechnology Initiative. It changed the face of the planet when you make that kind of commitment with that kind of leadership.

Secondly, I would agree with Randy that the military applications in DARPA, and I know the jurisdiction of your committee does not extend across that bridge at that point but you have the other federal granting agencies. The military applications are truly significant in information technology and commercialization and a lot of other things that wouldn't otherwise be commercialized but for the military application.

I guess I will close with a plea. Congress being the institution that it is, I guess that is with my tongue lodged firmly in my cheek. I would have a concluding request that maybe there could be more collaboration between congressional committees and congressional research, if you will, so you tie together the defense applications and the DARPA applications with the work of your committee's jurisdiction which is more effective.

Chairman SMITH. Dr. Freeman.

Dr. FREEMAN. I will observe what I think almost all of my colleagues have said, and that is when you step back from it, it is the programs that support the fundamental research, basic research, that in the long run have the greatest impact on industry. I would point to the example that I mentioned and that you elaborated on of Google. That was a basic research project. We had no idea when that was funded back in '92, '93 that it would produce a Google.

That wasn't the objective of it. It was a funding of a basic research proposal by some well-known Stanford professors. There was a big program at NSF at the time to fund basic research on digital libraries. Indeed, that program has been very seminal in a lot of ways. That created a part of an ecosystem in which two young graduate students were exploring algorithms.

The surrounding ecosystem of Stanford of Silicon Valley permitted them to say, "Um, that is an interesting idea. I wonder what we could do with it." In classic Silicon Valley fashion they went out and turns out it wasn't a garage. I believe it was an extra room in the home of one of, I think, Larry Page's girlfriend's parent's house when they decided that this had commercial possibilities.

Chairman SMITH. Thank you.

I yield to the gentleman from Texas, Mr. McCaul. I recognize him for any questions.

Mr. MCCAUL. Thank you, Mr. Chairman. I had one round so I am going to cover four areas. We have so much expertise here and I don't want to limit it. Feel free to jump in if you want to answer. I was not a math or science major. I was a history major.

In 1957 the Soviets launched Sputnik. We had a decision to make within the government at that time, to either shrink from that responsibility and that challenge, or lead that challenge. We all know what happened. We met the challenge not only in 1957 but in the '60s in the space race and President Kenney's call to land a man on the moon, which we did achieve by the end of the decade.

I believe in federal investment and it is a tough budgetary time. There is no question about it. It might be too high but if there is ever a federal investment to make, it is in research and development. We have seen the success from the space race but we also saw success and see it today, not only at the federal level but at the state level with the enterprise found in emerging technology.

In fact, CEO Keith McGavin told me the reason why he decided to take a stand in Texas in the Austin area was because he couldn't say no. I think the governor through his work certainly helped with the expansion of \$3 to \$5 million potential, we should say, investment in this area is due to the fact we are ready to invest at the

federal and state level in these companies and in these technologies.

I am always fascinated with the ecosystem, as you call it, the relationship, the synergy between the universities and private sector. The Federal Government plays a role as well. The National Academy of Sciences has said that Austin ranks at the very top of the list of cities. Because we have this unique relationship, we have the best minds in the world here. We have some of the best high tech companies also here. I know Lamar and I want to do everything we can to make that grow.

My question to the panel, and I agree with Dr. Sanchez this is a national security issue as well because we have global competition, as we had the space race, with China and India. We are losing our talent, and yet we are not able to educate K through 12 and instill this interest, if you will, to the point we are having to import scientists and engineers and outsource. I think it is a gathering storm that needs to be addressed.

The President's initiative ACI calls for: One, it doubles the combined budgets of NSF and the National Institute of Standards and Technology and the Department of Energy. Number two, it provides a place for education. Number three, those in the private sector, the R&D tax credit, which I think is fundamentally important to move forward.

The President made recommendations to us but we appropriate in Congress. We made decisions on how best to spend the taxpayer's money. I heard from your testimony everybody is very supportive of ACI but can you perhaps look at how you would tweak that if you were a member of the Congress sitting in the position that Congressman Smith and I are sitting in?

Dr. Goodall. Excuse me.

Dr. GOODALL. So I will tell you one thing specifically, having read the reports, both the *Gathering Storm* report for the National Academy and the ACI documentation itself, in the realm of education, in particular high school education, because I agree with doubling the physical science budgets, R&D tax credit straight down the line. I think in the area of education one of the things that I would like to see is more dollars applied to bringing industry people back into the educational system.

There is what I consider to be a small almost trivial amount of money applied to that. We can argue the philosophy of how much teachers should be paid but the fact is it will not bring reasonable scientific and engineering leadership examples, leadership for kids, back into the educational system without the appropriate amount of subsidy for them to really engage in that system. I think the tens of thousands of them engage within the educational system. If you want to make a lifetime commitment to doing something like that, changing kids' lives, I think it is going to be—it is not going to be getting jobs.

It is not going to be a philanthropic principle that needs to be a lifestyle degree and so I would like to see more money applied to the subsidizing program in education K through 12, especially high school. In particular with the challenged portion of school districts where kids just don't have that kind of leadership.

Chairman SMITH. Anybody else?

Dr. SANCHEZ. Well, in the scientific and research community, I am going back to the word prioritize but I think we should and we must find a way of prioritizing the investments and in a way that will maximize the economic impact on the Nation. A factor of two, doubling the budget, is great but you need to ask yourself why a factor of two. I think there is the cause and the recommendation that there is a shortfall in the funding of physical sciences.

It is direct and clear. We ought to correct that problem. The challenge is how to do that. What is the key? I think the agencies that have been chosen to implement or manage that investment are the right ones. The challenge for those agencies will be how to implement that significant investment. I am sure it is in good hands and I am sure it will be properly managed.

Chairman SMITH. Dr. Freeman.

Dr. FREEMAN. I would certainly agree that the ACI is a great start. As my colleagues have already pointed out, there are additional things that can be done. One was mentioned in education. Mr. Powers, I think, in his testimony mentioned the funding of technology transfer, although I think we need to think more creatively than just the scientists who are creating it and we have to somehow transfer it but the whole idea of getting new ideas into practice sooner. I would simply note that the *Gathering Storm* report has, I think, 22 recommendations in it so there is clearly a lot more that can be done as we go forward.

Mr. POWERS. Just a quick comment, Congressman McCaul. One part of the President's ACI program, as I understand it, would emphasize his pro-growth economic agenda by stimulating a business environment where innovators and entrepreneurs are rewarded. Let me put in a plug or a note for entrepreneurial training education programs and that sort of fundamental approach. Taking people in the science and scientific community and science disciplines and according them a proper entrepreneurial education. I think the new professors and new hires at colleges ought to be interviewed or reviewed in part for new hires based on their entrepreneurial intent. In other words, is this professor going to ultimately help commercialize technology or not? That ought to be part of the employment decision. I think we ought to encourage entrepreneurial training.

Mr. MCCAUL. That is a nice segue. In the interest of time I want to move on to the next topic and that is the tech transfer of intellectual property and venture capital for commercialization. SEMATECH takes good ideas to the marketplace, I believe.

The most important tech transfer is the students that get transferred from the universities to the private sector. That is the next generation of technology. When I got a tour of the research and development in the university I saw really a two part deal. I saw a lot of students who we had invested in in terms of money and training but they were probably 80 and 90 percent not from this country, primarily from Asia.

I asked if they were going to stay here as we need engineers. The answer I got was no, they are going to return and go back to China or where ever they came from. That troubled me because we were spending so much time and money to invest in them and then los-

ing them. They were going back and investing in places like China. I don't know what the answer is in terms of that.

The second question is that partnership between the university and the private sector can be hiring. We have, for instance, Samsung expanding, Hewlett Packard. Yet, our own students here being provided these highly skilled jobs or they won't make that jump into the marketplace.

Dr. SANCHEZ. Well, my view is that science and engineering is a global enterprise. Those students do contribute during the time they are here. Those that go back we lose. It is critically important for the health of research activities in this country that we continue to work openly with the colleges. I don't have clear statistics but I would guess that a good number of Nobel prize winners over the last several years have been born overseas.

There is a significant return on the investment. It is diminished. We don't have the same involvement in research and development as we used to but that seems to be the nature of the new global economy where not only are those students returning to their place of origin but we do have native American companies that are moving their research and development activities overseas. That is a serious challenge. The only answer to that is for us to create the environment in this country. That will be our challenge.

Mr. POWERS. Congressman, the *Rising Above the Gathering Storm* report has a comparative economic statement. When asked in the spring of 2005 which is the most attractive place in the world to lead a good life, whatever that means, respondents in only one country out of 16 countries polled indicated the United States.

I would submit it is equally important beyond money and policy programs that we build cultural relationships that communicate and connect like we have in Austin emphasizing why this World Congress on Information Technology is a world event with 2,100 delegates from 80 countries being at Austin is a deliberate attempt for us to showcase what makes a difference. I think we have a unique relationship and collaboration with others. I would close by saying we need to bring that to the national stage as part of your policy, part of what you guys do.

Mr. MCCAUL. That is a great point. Anybody else care to comment?

Dr. ISCOE. Let me just add on to that. So this WCIT in Austin, Texas, come move your company here because it is a good place to be. It really is a situation where it is a country providing an environment where people want to stay as opposed to going back to their country. Most of my life has been in industry and I have been, as director, sponsor of many, many H1B visas all throughout the citizenship chain. There are many people who are staying. I think it is possible, as Pike said, to make the environment in which we can make a place that people will remain and keep our competitiveness.

Dr. GOODALL. Maybe I will just reiterate my previous point is that we need to grow our own. The kids that you maybe were hoping to see populate the university would come from American high schools and they are not coming from American high schools. I think there is a profound failure somewhere in our education system, maybe even our social system, that is leading to that and I

think we need to find a way to overcome it and to rekindle the imagination of kids, specially those who don't have—in Austin your dad might work in a high-tech company. If you are in Nacogdoches maybe he doesn't and so we need to find ways to bring the world of technology to kids who live in areas where technology isn't there. The future of technology is going to be quite distributed. The centralization era is probably over for technology and it is going to be possible as we see in a lot countries who are bootstrapping kind of for nothing rather than the industrial basis that we have.

The Internet puts people wherever they need to be. Wherever they want to live they can be but you have got to understand that science and technology can allow you to live in your hometown and still be an entrepreneur in the technology area if you have the right activities and the right connections to regional infrastructure. I talked to a guy who is from Red River, a little town of 3,000, trying to understand how do I get the kids in our high school to just not leave town and never come back.

We were talking about some old system where you could just pack some technology into a van and take it to high schools around that region and show kids what is really going on. I think if we don't figure out how to do that, that we will only be able to retain the rest of the world's people as best we can or we won't be able to populate our universities and eventually our companies with our own people.

Mr. McCAUL. I agree that it is a problem. The advanced placement program is a good idea but it is a very, very difficult challenge we have. Again, in technology we face real crisis with our energy policy. We have had one for a decade. Congressman Smith and I voted for the Energy Bill that provides money to ramp up production and \$5 million for all-target technology.

I see Austin is a great sort of opportunity probably in the alternative, particularly at the university where we do have research being done on hydrogen fuel cells and we are working hard to make sure in the future that DOE will fund that. We have in the science community the H-Prize which was awarding prize money to somebody who can develop hydrogen storage facilities, a hydrogen vehicle that is cost effective. It is a challenge for the private sector as well. I think this is probably one of the biggest national security issues of the day. This is the future.

Dr. SANCHEZ. The set of conditions that are currently evolving around the energy situation, people refer to this as the Perfect Storm. There is no issue more critical to the Nation. Texas for historical reasons is in a position to make major contributions to that. The solution is not really a solution to energy.

It is not just enhance automobile production but it is extremely important that we have technologies and use everything we know about technologies and nanotechnology to increase production in Texas and elsewhere. The problem, as I see it right now, we are not moving fast enough in finding those alternative technologies that will transition us to a new one.

I live in western Texas and I think we do cover the entire range of technologies that relate to it. We have developed a strategic plan for an institutional approach to answer those questions rather than typical departmental approach and we will implement that plan.

That plan has been to the table. Congress has a stake in the future so we are absolutely working on it.

Mr. MCCAUL. Anyone else care to comment? I know the time is brief.

The last issue, security. We had a recent intrusion here. I remember testifying before Lamar Smith when he was Chairman of the Subcommittee. I am very honored to sit with him now as a colleague.

Security is an issue that I studied and it is always a concern to a great deal, the idea of a foreign power. Our military has the capability to shut down foreign powers. It is a matter of time before they get through to us. We saw a recent intrusion at the university and I just wanted to ask how secure are we on this issue?

Dr. SANCHEZ. Well, I don't think anyone is entirely secure or anyone that wants to be connected to the Internet is 100 percent secure. It is a moving target but we are making progress in this area. It is not just the University of Texas. It is every university in the country which is challenged by these two competing needs. One is to be secure, to protect data, to protect research data, to protect financially on the one hand. But on the other it is to provide an environment that will allow researchers to communicate and transfer data. It is really a major challenge.

The answer, I'm sure, is somewhere. We have the tools to be 100 percent secure. I am not an expert in the subject but I do see two competing interests. Be open so that we can create this data system that we are talking about and will we benefit from access to the information. And, on the other hand, to protect the information.

Mr. MCCAUL. Thank you, Mr. Chairman.

Chairman SMITH. Congressman McCaul, thank you for those great questions. I do want to say something you and I are both interested in. Elizabeth Grossman just reminded me that the Science Committee is developing legislation—I am sure we will both cosponsor—on K through 12 and undergraduate education.

These are some of the provisions in that legislation which may come out as soon as next week. K through 12 teacher training and professional development, scholarships for math and science majors who become teachers, curriculum development at the undergraduate level, improved math and science courses for teaching, interdisciplinary programs. Dr. Freeman, you will be hearing from us once again.

We thank you all again for your participation today and for your expert testimony. It is valuable to us. I just have to tell you I learn day after day that there is simply no substitute for person-to-person communication and person-to-person communication of knowledge that we otherwise might not have, so this is all very, very important to us.

As I say, we have records of everything. We will take the testimony back to Washington and use that to I hope follow up on your suggestions. We share your concerns about what we need to do. We certainly share an interest in making sure that we have a healthy commercial economy. I thank you all again. We stand adjourned.

[Whereupon, at 4:10 p.m., the Committee adjourned.]